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Subject: **Geophysical Survey at the Wilcox Refinery Superfund Site in Bristow, OK**

GEOPHYSICAL SURVEY METHODS

EM31 Terrain Conductivity Meter

EM31 terrain conductivity is used extensively for environmental and geotechnical applications such as delineation of buried wastes, soft or wet soils, and potential sinkholes. The EM31 is an electromagnetic system with a transmitter coil mounted on one end and a receiver coil at the other end of a 12-foot long plastic boom. An audio-frequency alternating current is applied to the transmitter coil, causing the coil to radiate an alternating primary EM field. The time-varying magnetic field generates eddy currents in subsurface materials which have an associated secondary magnetic field with a magnitude and phase shift (relative to the primary field) that is dependent on the conductivity of the medium. The receiver coil measures the resultant effect of both primary and secondary fields. By comparing the signal at the receiver to that at the transmitter, the instrument records the components of the secondary field inphase (inphase data) and 90 degrees out-of-phase (quadrature/conductivity data) with the primary field.

The EM31 is configured so that the out-of-phase component is converted to bulk electrical conductivity in units of millimhos per meter (mmhos/m). The measured conductivity is an apparent conductivity that is the result of the various subsurface materials that are sampled by the EM field. It is referred to as terrain conductivity. The inphase component is read in parts per thousand (ppt) of the primary EM field and is generally adjusted in the field to read zero response over background materials. The inphase component generally represents current density and is a gross measure of the presence of buried ferrous metal debris.

The EM31 has a maximum effective exploration depth of approximately 5.5 meters (18 feet) when operating in the vertical dipole mode (horizontal coils) with the instrument at normal operating height of about 0.9 meters (3 feet). In the horizontal mode (vertical coils), the EM31 has an effective exploration depth of about nine feet and is most sensitive to materials immediately beneath the ground surface. The EM31 data were collected in the vertical dipole mode for this project.

Before the EM31 survey was conducted, a site base station was established. During the first day of data collection, the EM31 was calibrated to this base station. The background conductivity values ranged from 14 to 16 mmhos/meter. At the beginning of each field day, the EM31 was field calibrated at this base station. A second base file was collected at the end of each field day. Collection of base files at a consistent location is performed in case there is drift in the data due to atmospheric conditions. During the course of the investigation, morning background conductivity readings recorded at the base station varied between 14 and 16 mmhos/meter. A background reading of 14 to 16 mmhos/m was recorded for the terrain conductivity. The inphase reading is adjusted to zero ppt in the field. After the instrument was field calibrated, a base file was recorded and saved in the data logger memory. The base file collected a minimum of 30 seconds of EM data in the vertical dipole mode. Collection of base files each day also demonstrates that the EM31 is functioning properly.

Before collecting field data, the data logger was programmed with the appropriate file name and recording parameters. Header information imbedded in the file contains the operator's initials and a time/date stamp. The data logger, an Archer 2® field pc, digitally stored the EM31 data and the horizontal positioning data. The Archer 2® has an internal global positioning system (GPS). EM31 and GPS data were collected simultaneously at a rate of 15 readings per second.

Ground Penetrating Radar

GPR is an electromagnetic instrument that transmits and records radar EM pulses. GPR systems produce cross-sectional images of subsurface features by transmitting discrete radar pulses into the subsurface and recording the echoes or reflections from interfaces between materials with differing dielectric properties. To conduct a GPR survey, an antenna containing a transmitter and a receiver is slowly pulled along the ground surface. The transmitter radiates short pulses of high frequency EM energy into the ground. When the wave encounters the interface between two materials having different dielectric constants (dielectric permittivity), a portion of the energy is reflected back. The contrast in dielectric permittivity between the two media can be quantified by a reflection coefficient at the media interface. The magnitude of the reflection coefficient increases as the contrast in dielectric constant increases. The signal is transmitted to a control unit, displayed on a color monitor, and digitally recorded.

The effective penetration depth of a radar system is controlled by the dielectric permittivity, the electrical conductivity (usually dictated by moisture content) of the soils and the frequency of the antenna. In highly conductive materials (such as clay), the pulse is dissipated at very shallow depths. Two-way travel time on the GPR records can furnish estimates of depth if the dielectric constant for subsurface materials is known. If it is unknown, then an approximate depth can be obtained by using published average dielectric constants for the site soils.

Resolution of the GPR system is dependent on the frequency of the antenna used during the survey. Very high frequency antennae (900 megahertz [MHz] or greater) can resolve small features (less than an inch in diameter) but can penetrate to a maximum depth of 2 feet or shallower. Lower frequency antennae (100 to 500 MHz) can resolve objects deeper in the subsurface (up to 50 feet BGS, depending on soil conditions) but usually miss objects near surface. There is a tradeoff between depth penetration and resolution; in some cases it may be necessary to utilize two or more antennae to collect the necessary depth and resolution information.

The GPR antenna is calibrated by the manufacturer. In order to document the antenna and GPR are functioning properly a test line is performed each day. Similar to the base station used with the EM31, a single line is marked on the ground surface and a test line is recorded along this line at the beginning and end of each field day. Although the resulting GPR images will not be duplicates of each other (due to daily soil moisture content), the images will be similar and they will demonstrate that the GPR and antenna are operational.

During the initial test line, operating and recording parameters such as the range (amount of time the instrument records after transmitting an EM pulse), scan rate (number of recorded traces or scans per second), transmitter pulse rate (frequency at which the EM pulses are transmitted), instrument gains, and filter settings. These settings are automatically stored in a header file with the digital GPR data. At the beginning of each day, the GPR retrieves these parameters from the internal project folder.

A SIR3000 GPR unit with a 400 Megahertz antenna, both manufactured by GSSI, Inc. of North Salem, NH, were utilized during this investigation. In order to record horizontal positioning data, an external GPS unit was mounted to the GPR survey cart. The SIR3000 records time stamps which are matched to time stamps recorded by the GPS. The RADAN7 GPR processing software, then merges the two files based on the time stamps. The time stamps are based on satellite time, not the local time zones.

GEOPHYSICAL DATA PROCESSING

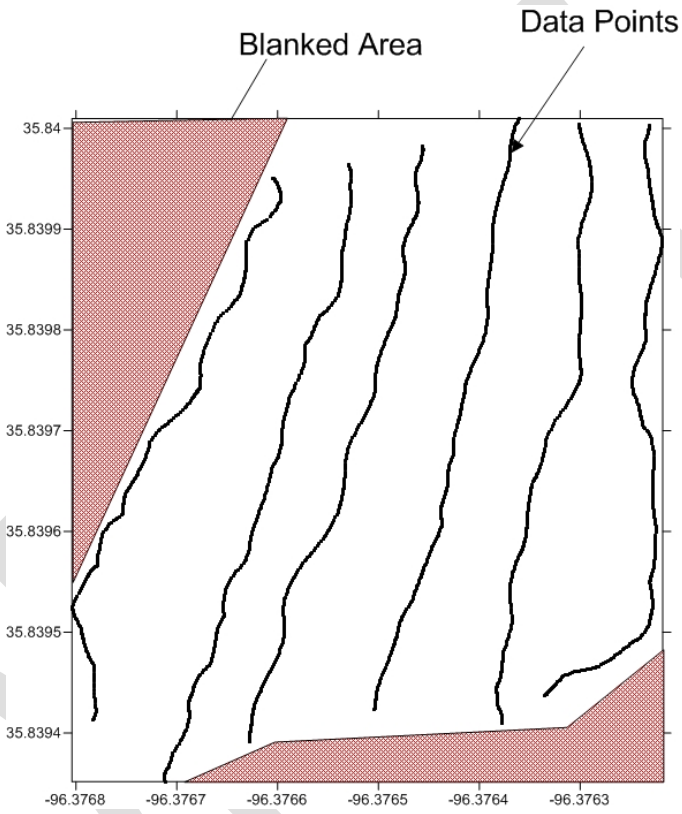
EM31 Data Processing

At the end of each field day, the Archer 2 field PC, was downloaded. The individual EM31 files are sorted by investigation area. Once sorted, the EM31 raw data files (files with an extension *.R31) are imported into the manufacturer supplied DAT31™ software. This software opens the *.R31 file and merges the GPS data together. The file is then saved as a data file with the *.G31 extension. This file is then exported as a data file in an XYZ format that is readable by the contouring software package Surfer© (Golden Software, Inc.).

The XYZ file (file extension *.DAT) includes the following data columns: longitude, latitude, conductivity, inphase, date, and time. If multiple data files were collected in the same investigation area over several days, the files were merged into one data file for contouring. In each investigation area, one EM31 data file was created. The EM31 data file was also prepared

for entry to the SCRIBE software package. An additional column was added to the file (Location ID).

Each Investigation Area data file was processed through Surfer to create a color-contour figures representing the conductivity and inphase. A data post map was created to show the location of each data point collected within the Investigation Area. Because survey areas are rarely square, the post map will show areas that were not part of the survey area in order to incorporate the irregular shaped survey area. The following figure shows how the data is posted and the areas where no data exists are blanked.



These areas that are not part of the survey area are blanked out prior to contouring the data. By blanking out these areas, the contouring software does not try to include these areas where there is no actual data.

The blanked file is then gridded using Kriging method. Two gridded sets are created (conductivity and inphase). A color contour interval scale is created to accommodate all of the investigation areas. It is preferred to create a consistent color contour scale to be used for all EM data on a particular site. In this survey, the EM31 conductivity scale was set to range from 0 to 100 mmhos/meter and the inphase scale was set to -20 to 2- ppt.

In several investigation areas, the conductivity values were negative. Negative conductivities do not occur in nature. The negative value is caused by the EM31 going off scale (greater than 1,000 mmhos/meter, the software is programmed to record this data as a negative value. For the purposes of these investigation areas, the negative conductivities corresponded to areas where

surface metal was present as well as areas where elevated conductivities were being recorded within scale therfore the negative values were not shown separately on the EM31 conductivity figures.

The inphase scale generally ranges from -18 to 18 ppt. Inphase readings of -3 to 3 ppt are generally considered background readings. Both ends of the contour scale (greater than 10 ppt and less than -10 ppt) are considered to be influenced by the presence of metal.

Interpretation of EM31 Data

Terrain conductivity surveying is a reconnaissance method of determining the electric and magnetic properties of subsurface materials. The conductivity measurement is dependent upon the density, porosity, moisture content, and the presence or absence of electrolytes or colloids in the subsurface materials. Because of the variety of factors that affect terrain conductivity measurements, the actual magnitude of the terrain conductivity values measured is less important than the trends and anomalies in the measurements.

An EM survey, which measures the conductivity of a volume of the subsurface, can be used to gauge the relative amounts of soil and rock within the area of measurement. High apparent conductivity measurements would imply a thicker soil cover and low or no rock volume present, while lower apparent conductivities would suggest a greater effect from bedrock, therefore indicating a thinner soil cover.

Very low conductivity values [approaching 0 mmhos/meter (mmhos/meter)] are usually the result of cultural interference but may also indicate air space and possible voids. The theoretical conductivity of air is 0 mmhos/meter. Utilities (above and below the ground surface) can significantly impact the data quality. Utilities observed while the geophysicist is collecting the data are noted in field notes and incorporated into the data processing and highlighted on the report figures when they are present.

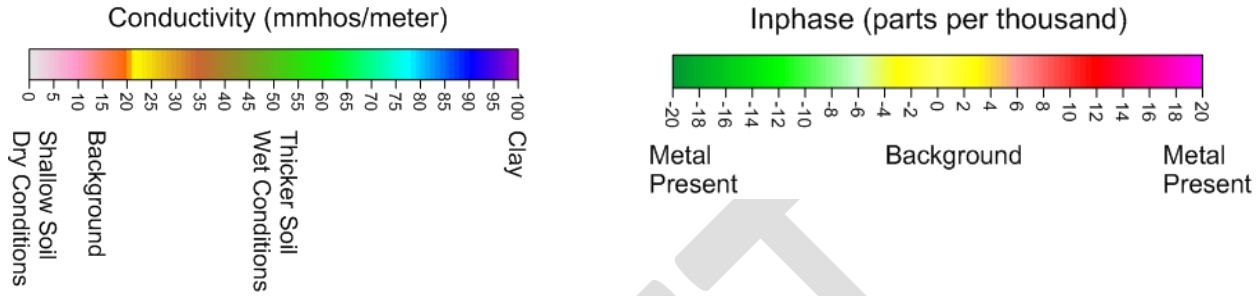
A major objective of geophysical survey at the Wilcox Refinery Site was to delineate areas of hydrocarbon impacted soil. Crude oil contains impurities that will cause the conductivity values to be elevated. However there is insufficient metals in the crude oil to cause the inphase readings to be elevated. Therefore, the EM31 data plots were reviewed for areas of high conductivity with low inphase readings. If the conductivity was elevated but the inphase was elevated as well, the data indicates the presence of metal.

Areas with low conductivity and low inphase values are typically thin soils or dry conditions. When an anomaly registers a low conductivity but a high inphase reading, surface interference is generally suspected.

During test pitting at the site, another set of conditions was encountered. An area of very high conductivity values with near background inphase values was detected at an investigation area.

When a test pit was conducted at this location, a dense clay layer was encountered approximately 3.5 feet below the ground surface (BGS). Clay will elevate conductivity values.

Based on the EM data collected during this investigation and comparison to known site conditions, the following color scales for the conductivity and inphase were adapted.



GPR Data Processing

The GPR files are downloaded to a computer along with the GPS data. The RADAN7 software package merges the two files together. The resultant file can be used to highlight individual anomalies or highlight layers within the subsurface.

Each GPR file is first corrected for the surface wave. On a raw GPR file, there is a banded reflection at the top of the profile. This is the surface wave and is caused by the GPR energy hitting the ground surface directly beneath the antenna. The surface wave is removed to correct the depth scale. Once the surface wave is removed, the edited file is opened and the top of the profile will show 0 feet (depth) and the band is gone.

Because the objective of the GPR survey is to determine the depth to rock, the GPR profiles were reviewed for layers. When individual anomalies of interest, such as pipes, were observed they were noted as well. During processing the color scale of each of the profiles is kept in the black-gray-white scale.

The next step is to adjust the gain on the data. The gain is adjusted up or down depending on each profile. Normally the adjustment is minor but necessary to highlight some anomalies. The gain needs to be turned up in order to see small or unclear anomalies. But turning the gain up too high will cause all of the data to appear washed out. The concept is similar to audio- turn the music up loud enough to hear, but if it is too loud it is all noise.

After adjusting the gain, each profile was reviewed for the layer interpreted to be the top of bedrock. Information collected on the site, including visual observations, indicated the bedrock could range from 3 feet BGS to greater than 15 feet BGS. Since the GPR files are tied to GPS, the interpreted top of bedrock was highlighted on the profile and then exported as a comma delimited XYZ data file. The XYZ file (file extension *.CSV) includes the following data columns: longitude, latitude, depth to rock, surface elevation, elevation of bedrock, and date. The GPR files were exported individually but combined to one file for creating a top of bedrock elevation figure. An additional column (Location ID) was included for the file prepared for entry to the SCRIBE software package.

The GPR profiles were saved as image files (*.jpeg). Several GPR profiles have been included with this report. All of the GPR profile images will be submitted with the final report on a DVD.

Interpretation of GPR Data

A GPR records the echoes and reflections between interfaces to produce cross-sectional images. All media have a dielectric constant, the greater the difference between the dielectric constants of the two adjacent materials, the brighter the reflection (or color) will be on the GPR profile. It is important to remember that the color scales provided on GPR profiles represent the change in dielectric constants. The greater the difference in dielectric constants – the brighter the reflection will be on the profile. The color scales are unit-less.

The following table includes dielectric constants of materials encountered at the Wilcox Refinery.

Media	Dielectric Constant
Air	1
Water	81
Sand (Dry)	3-6
Sand (Wet)	25-30
Clay (Wet)	8-15
Clay (Dry)	3
Silt	10
Sandstone	6
Petroleum	2

When the change between two materials increases- for example going from a dry sand to a wet sand the color will shift to the right on the scale. When the change represents a decrease – such as silt to sandstone- the color will shift to the left on the scale.

At the Wilcox Refinery Site, the overburden material is primarily silt and sand, some clay was also observed. Since each of these materials would involve a dielectric shift to the right (increase) when the sandstone was encountered, the GPR profiles were reviewed for a bright, continuous reflection.

On many of the GPR profiles more than one bright, continuous reflections were observed. These areas were selected for test pits in order to determine what the multiple layers represented. After test pits were completed, the more shallow reflection was found to be layers of clay/clayey silt. The deeper reflection was determined to be the top of the bedrock.

GEOPHYSICAL SURVEY RESULTS

The following sections include the geophysical results for each of the investigation areas. Figures discussed in each of the sections are included in Appendix A. These results were based on the geophysical surveys data as well as the test pits that were completed during the geophysical survey. Additional drilling is planned at the site, data collected from the additional drilling will be used to refine the geophysical survey results.

Figure 1 depicts the site divided into five survey areas. These divisions were based on information obtained from historical photographs and other information sources. The geophysical survey concentrated on three of the survey areas: East Tank Farm, Lorraine Process Area, and Wilcox Process Area.

East Tank Farm

The East Tank Farm was divided into 11 Investigation Areas (IA). These IAs are shown on Figure 2 and were based on the historical photographs depicting possible above ground storage tanks (ASTs) or surface impoundments. All of the IAs required at least some brush clearing in order to perform the geophysical survey. Extensive brush clearing was performed in some of the IAs along the western portion of the East Tank Farm. Three of the IAs were eliminated from geophysical surveys due to dense underbrush and inability to access these areas.

Figures 3 and 4 present the EM31 conductivity and inphase data, respectively, collected over the East Tank Farm. Figures 5 and 6 present the bedrock elevation and soil thickness contours based on the interpreted GPR data, respectively. The following sections depict the results divided into individual IAs.

Investigation Areas 1, 2, and 4

IA1 was eliminated due to the dense brush. An attempt was made to survey IA2; however, the wet conditions at this location interfered with the GPR and EM31 data. IA4 was eliminated due to the dense brush. Figure 7 shows the locations of these three IAs.

Investigation Area 3

IA3 is located on the eastern side of the site, as shown on Figure 2. Figure 8 presents the EM31 conductivity data and Figure 9 presents the inphase data collected in IA3 using the site wide standardized color contour scales. The actual conductivity data ranged from 4 to 28 mmhos/m and the inphase data ranged from -1 to 2 ppt. The EM31 data collected at IA3 does not show the presents of any significant anomalies. The conductivity is lower on the west and central portions of the survey area. The inphase readings are within the acceptable background interval. The data does not indicate the presence of metallic features. The presence of low conductivity values coupled with no inphase response most likely indicates shallow bedrock in the central and western sections compared to deeper rock to the north and east within the survey area.

Figure 10 shows the locations, direction of travel, and profile identifier of the GPR files collected in IA3. Locations of individual anomalies detected by the GPR that are not linear features interpreted to be bedrock are shown on Figure 10. Example profiles are presented in Figure 11.

Figure 12 presents a color-contour interval map of the interpreted bedrock elevation. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges between 776

feet and 787 feet above mean sea level (AMSL). When subtracting the bedrock elevation from the ground surface elevation the soil thickness is calculated. Figure 13 includes the soil thickness map which is similar to the EM31 data in that it shows the thickness of the soil to range from approximately 7.5 to 12 feet.

Investigation Area 5

IA 5 is located on the north east corner of the site, as shown on Figure 2. Figure 14 presents the EM31 conductivity data and Figure 15 presents the inphase data collected in IA5 using the site wide standardized color contour scales. The actual conductivity data ranged from -49 to174 mmhos/m and the inphase data ranged from -20 to -26 ppt. The negative conductivities and extremely high readings are caused by interference from surface features. Underground and overhead utilities have been noted on Figures 14 and 15. The low conductivity values (ranging from 12 to 25 mmhos/m) have been interpreted to represent shallow bedrock. In the central portion of the EM31 survey data, higher conductivities (50 to 75 mmhos/m) were observed. These elevated readings may indicate the soil has been impacted by hydrocarbons or the soil is thicker in this area. The inphase data shows only two other anomalies besides the utilities. Both of these have been attributed to surface features.

Figure 16 shows the locations, direction of travel, and profile identifier of the GPR files collected in IA5. Locations of individual anomalies detected by the GPR that are not linear features interpreted to be bedrock are shown on Figure 16. Example profiles are presented in Figure 17.

Figure 18 presents a color-contour interval map of the interpreted bedrock elevation and Figure 19 includes the interpreted soil thickness. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges between 810 to 834 feet AMSL. The soil thickness map which is similar to the EM31 data in that it shows the thickness of the soil to range from approximately 3 to 8 feet, with the slightly thicker areas being located in the central portion of the survey area.

Investigation Area 6

IA6 is located on the north perimeter of the site along the public road. This survey area is nearly bisected by the barbed wire fence. Along the east end of the fence is a pond. Figure 20 presents the EM31 conductivity data and Figure 21 presents the inphase data collected in IA6 using the site wide standardized color contour scales. The actual conductivity data ranged from -54 to 92 mmhos/m and the inphase data ranged from -15 to 20 ppt. The negative conductivities and extremely high readings are caused by interference from surface features. The low conductivity values (ranging from 12 to 25 mmhos/m) have been interpreted to represent shallow bedrock. The presence of the fence has caused an elongated anomaly.

In the central portion of the EM31 survey data, higher conductivities (25 to 35 mmhos/m) were observed. These elevated readings may indicate the soil has been impacted by hydrocarbons or the soil is thicker in this area. The inphase data shows only one anomaly which is located on the north side of the survey area. This has been attributed to the fence.

Figure 22 shows the locations, direction of travel, and profile identifier of the GPR files collected in IA6. Locations of individual anomalies detected by the GPR that are not linear features interpreted to be bedrock are shown on Figure 22. Example profiles are present on Figure 23.

Figure 24 presents a color-contour interval map of the interpreted bedrock elevation and Figure 25 includes the interpreted soil thickness. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges between 804 to 840 feet AMSL. The soil thickness map which is similar to the EM31 data in that it shows the thickness of the soil to range from approximately 4 to 15 feet. The orientation of the GPR profiles in this IA was primarily northwest to southeast which has caused the contours to appear elongated in that directions.

Investigation Area 7

IA7 is located on the north perimeter of the site along the public road and adjacent to the pipeline pumping station (Figure 2). This IA also includes a survey area where there were several ASTs in a cluster. The survey areas were joined together during data collection. Figure 26 presents the EM31 conductivity data and Figure 27 presents the inphase data collected in IA7 using the site wide standardized color contour scales. The actual conductivity data ranged from -18 to 100 mmhos/m and the inphase data ranged from -20 to 13 ppt. The negative conductivities and extremely high readings are caused by interference from surface features, in this IA the pipeline. The low conductivity values (ranging from 12 to 25 mmhos/m) have been interpreted to represent shallow bedrock. The inphase data shows one significant anomaly which is the pipeline traversing the survey area from southeast to northwest.

Figure 28 shows the locations, direction of travel, and profile identifier of the GPR files collected in IA7. Locations of individual anomalies detected by the GPR that are not linear features interpreted to be bedrock are shown on Figure 28. Example profiles are present on Figure 29.

Figure 30 presents a color-contour interval map of the interpreted bedrock elevation and Figure 31 includes the interpreted soil thickness. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges between 782 to 820 feet AMSL. The soil thickness map which is similar to the EM31 data in that it shows the thickness of the soil to range from approximately 5 to 15 feet. The orientation of the GPR profiles in this IA was primarily northwest to southeast which has caused the contours to appear elongated in that directions.

Two test pits were conducted within the IA7 area. They are labeled as TP7 and TP8 and are shown on the IA7 figures. Field notes from TP7 indicated the presence of sand and sandy clay to a depth of 5.5 feet BGS. Hard gray clay was encountered at 5.5 feet BGS; however, bedrock was not encountered. The depth to the top of the bedrock was interpreted from the GPR profiles to be greater than 7.5 feet at the TP7 location. Field notes from TP8 indicated the presence of sand and clay to a depth of 7.4 feet BGS. Bedrock was not encountered during the excavation. The depth to the top of the bedrock was interpreted from the GPR profiles to be greater than 7.5 feet at the TP8 location.

Investigation Area 8

IA8 is located on the east-central part of the site (Figure 2). This survey area is nearly bisected by the barbed wire fence. Figure 32 presents the EM31 conductivity data and Figure 33 presents

the inphase data collected in IA8 using the site wide standardized color contour scales. The actual conductivity data ranged from 16 to 167 mmhos/m and the inphase data ranged from -19 to 18 ppt. The very high conductivity values (>100 mmhos/m) may be an indication of the presence of hydrocarbon impacted soil The inphase data collected in the same area indicates data values slightly above the background readings. The EM31 low conductivity values (ranging from 12 to 25 mmhos/m) have been interpreted to represent shallow bedrock. The presence of the fence has caused as elongated anomaly.

Figure 34 shows the locations, direction of travel, and profile identifier of the GPR files collected in IA8. Locations of individual anomalies detected by the GPR that are not linear features interpreted to be bedrock are shown on Figure 34. Example profiles are present on Figure 35.

Figure 36 presents a color-contour interval map of the interpreted bedrock elevation and Figure 37 includes the interpreted soil thickness. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges between 802 to 834 feet AMSL. The soil thickness map which is similar to the EM31 data in that it shows the thickness of the soil to range from approximately 4 to 8 feet.

Four test pits were completed within the IA8 survey area. They are labeled as TP1, TP2, TP3, TP4a, TP5 and TP46 and are shown on the IA8 figures. Field notes from TP1 indicated the presence of sand and clay to a depth of 6.6 feet BGS. Bedrock was not encountered during the excavation. The depth to the top of the bedrock was interpreted from the GPR profiles to be approximately 5 feet BGS at the TP1 location. Field notes from TP2 indicated weathered rock was encountered at the depth of 4 feet BGS. The depth to the top of the bedrock was interpreted from the GPR profiles to be approximately 5 BGS.

TP3 was excavated within the very high conductivity anomaly. According to field notes recorded during the test pit, a dense wet clay was encountered at 2.3 feet below the ground surface. Wet clay would appear in the EM conductivity data has an elevated reading. Bedrock was not encountered during the excavation; however, the depth to the top of the bedrock was interpreted from the GPR profiles to be approximately 5 to 6 feet BGS at the TP3 location.

Field notes from TP4a indicated the presence of sandy clay to a depth of 3.7 feet BGS. Friable sandstone was found at 3.7 feet BGS. The depth to the top of the bedrock was interpreted from the GPR profiles to be approximately 5 feet BGS at the TP4a location. This difference may be due to the GPR detecting the competent/hard bedrock.

Field notes from TP5 indicated the presence of a black material approximately 2.2 feet BGS which may be the tar layer. Continued excavation of TP5 indicated the presence of sand and clay to a depth of 5.4 feet BGS. The depth to the top of the bedrock was interpreted from the GPR profiles to be approximately 6 to 7 feet BGS.

Field notes from TP6 indicated the presence of tar and oil below the grass. Sand and clay were present to a depth of approximately 3.6 feet BGS. Hard clay with some sandstone was present to a depth of 7.5 feet BGS when the excavation was stopped. The depth to the top of the bedrock was interpreted from the GPR profiles to be between 7.5 and 10 feet.

Investigation Area 9

IA9 is located in the southern portion of the site (Figure 2). Figure 38 presents the EM31 conductivity data and Figure 39 presents the inphase data collected in IA9 using the site wide standardized color contour scales. The actual conductivity data ranged from -33 to 43 mmhos/m and the inphase data ranged from 0 to 2 ppt. The negative conductivities and extremely high readings are caused by interference from surface features, and in this IA a previously unknown underground pipe. The low conductivity values (ranging from 12 to 25 mmhos/m) have been interpreted to represent shallow bedrock. The inphase data is considered to be background with no metallic features present.

Figure 40 shows the locations, direction of travel, and profile identifier of the GPR files collected in IA9. Locations of individual anomalies detected by the GPR that are not linear features interpreted to be bedrock are shown on Figure 40. Example profiles are present on Figure 41.

Figure 42 presents a color-contour interval map of the interpreted bedrock elevation and Figure 43 includes the interpreted soil thickness. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges between 790 to 812 feet AMSL. The soil thickness map which is similar to the EM31 data in that it shows the thickness of the soil to range from approximately 5 to 15 feet. Limited elongation of the data has occurred along the western side of the survey area due to the orientation of the GPR profiles.

Two test pits were conducted within the IA9 area. They are labeled as TP4b and TP9 and are shown on the IA9 figures. Field notes from TP4b indicated the presence of sandy clay to a depth of 6.1 feet BGS. Sandstone was encountered at 6.1 feet BGS. The depth to the top of the bedrock was interpreted from the GPR profiles to be greater than 7.5 feet at the TP4b location. Field notes from TP9 indicated the presence of sand and clay to a depth of 7.5 feet BGS. Bedrock was not encountered during the excavation. The depth to the top of the bedrock was interpreted from the GPR profiles to be greater than 10 feet at the TP9 location.

Investigation Area 10

IA10 is located in the central area of the site adjacent to a settling pond (Figure 2). Figure 44 presents the EM31 conductivity data and Figure 45 presents the inphase data collected in IA10 using the site wide standardized color contour scales. The actual conductivity data ranged from -35 to 126 mmhos/m and the inphase data ranged from -17 to 10 ppt. The negative conductivities and extremely high readings are caused by interference from surface features, in this IA a previously unknown anomaly with characteristics of an underground pipe has been detected. The location and orientation of this anomaly align with the unknown anomaly detected during the survey of IA9. The low conductivity values (ranging from 12 to 25 mmhos/m) have been interpreted to represent shallow bedrock.

In the southeast section of this survey area, the EM31 conductivity readings range from 65 to 95 mmhos/m. This location is adjacent to the settling pond which has hydrocarbon visible on the ground surface. Except for the unknown pipe-like anomaly, the inphase data do not indicate the presence of significant amounts of metallic material.

Figure 46 shows the locations, directions of travel, and profile identifier of the GPR files collected in IA10. Locations of anomalies detected by the GPR that are not linear features interpreted to be bedrock are shown on Figure 46. Example profiles are presented in Figure 47.

Figure 48 presents a color-contour interval map of the interpreted bedrock elevation and Figure 49 includes the interpreted soil thickness. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges between 774 to 804 feet AMSL. The soil thickness map which is similar to the EM31 data in that it shows the thickness of the soil to range from approximately 7.5 to greater than 10 feet.

Two test pits were conducted within the IA10 area. They are labeled as TP10 and TP11 and are shown on the IA10 figures. Field notes from TP10 and TP11 indicated the test pits were excavated to a depth of 9.5 feet and bedrock was not encountered. The depth to the top of the bedrock was interpreted from the GPR profiles to be at least 10 feet at these locations.

Investigation Area 11

IA11 is located in the western section of the tank farm (Figure 2), partially within the Wilcox Process Area. The area available for surveying was limited due to the brush and the perimeter fence. Figure 50 presents the EM31 conductivity data and Figure 51 presents the inphase data collected in IA11 using the site wide standardized color contour scales. The actual conductivity data ranged from -33 to 107 mmhos/m and the inphase data ranged from -11 to 9 ppt. The negative conductivities and extremely high readings are caused by interference from surface features, in this IA a previously unknown underground pipe. The low conductivity values (ranging from 12 to 25 mmhos/m) have been interpreted to represent shallow bedrock. The inphase data is considered to be background with no metallic features present.

Figure 52 shows the locations, directions of travel, and profile identifier of the GPR files collected in IA11. Locations of anomalies detected by the GPR that are not linear features interpreted to be bedrock are shown on Figure 52. Example profiles are presented in Figure 53.

Figure 54 presents a color-contour interval map of the interpreted bedrock elevation and Figure 55 includes the interpreted soil thickness. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges between 776 to 788 feet AMSL. The soil thickness map which is similar to the EM31 data in that it shows the thickness of the soil to range from approximately 5 to greater than 10 feet.

Investigation Area 12

IA12 is located south of the IA11 (Figure 2), partially within the Wilcox Process Area. The area available for surveying was limited due to the brush. Figure 56 presents the EM31 conductivity data and Figure 57 presents the inphase data collected in IA12 using the site wide standardized color contour scales. The actual conductivity data ranged from -63 to 168 mmhos/m and the inphase data ranged from -19 to 2 ppt. The negative conductivities and extremely high readings are caused by interference from surface features, in this IA influence from metal objects and fencing. The low conductivity values (ranging from 12 to 25 mmhos/m) have been interpreted to represent shallow bedrock. The inphase data is considered to be background with several small metallic features present.

Figure 58 shows the locations, directions of travel, and profile identifier of the GPR files collected in IA12. Locations of anomalies detected by the GPR that are not linear features interpreted to be bedrock are shown on Figure 58. Example profiles are presented in Figure 59.

Figure 60 presents a color-contour interval map of the interpreted bedrock elevation and Figure 61 includes the interpreted soil thickness. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges between 766 to 782 feet AMSL. The soil thickness map which is similar to the EM31 data in that it shows the thickness of the soil to range from approximately 7.5 to greater than 10 feet.

Wilcox Process Area

The location of the Wilcox Process Area is shown on Figure 1. Figure 62 presents the EM31 conductivity data and Figure 63 presents the inphase data collected within the Wilcox Process Area using a class-post color scale. There were insufficient data collected within the Wilcox Refinery to create a contour map. The classed post figure represents the data divided into actual ranges, not contours. There is insufficient EM data to interpret any significant anomalies.

Figure 64 shows the location, directions of travel, and profile identifier of the GPR files collected in the Wilcox Process Area. Locations of anomalies detected by the GPR that are not linear features interpreted to be bedrock are shown on Figure 64. Example profiles are presented in Figure 65.

Figure 66 presents a color-contour interval map of the interpreted bedrock elevation and Figure 67 includes the interpreted soil thickness. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges between 782 and 808 feet AMSL. The soil thickness ranges from approximately 8.5 to greater than 10 feet.

Lorraine Process Area

The location of the Lorraine Process Area is shown on Figure 1. Figure 68 presents the EM31 conductivity data and Figure 69 presents the inphase data collected with the Lorraine Process Area using the site side standardized color contour scales. The actual conductivity data ranged from -80 to 204 mmhos/m and the inphase data ranged from -16 to 20 ppt. Elevated conductivity readings indicate the presence of numerous anomalies that may represent piping or potential contamination. The inphase data were influenced on the west side of the survey area by the perimeter fence.

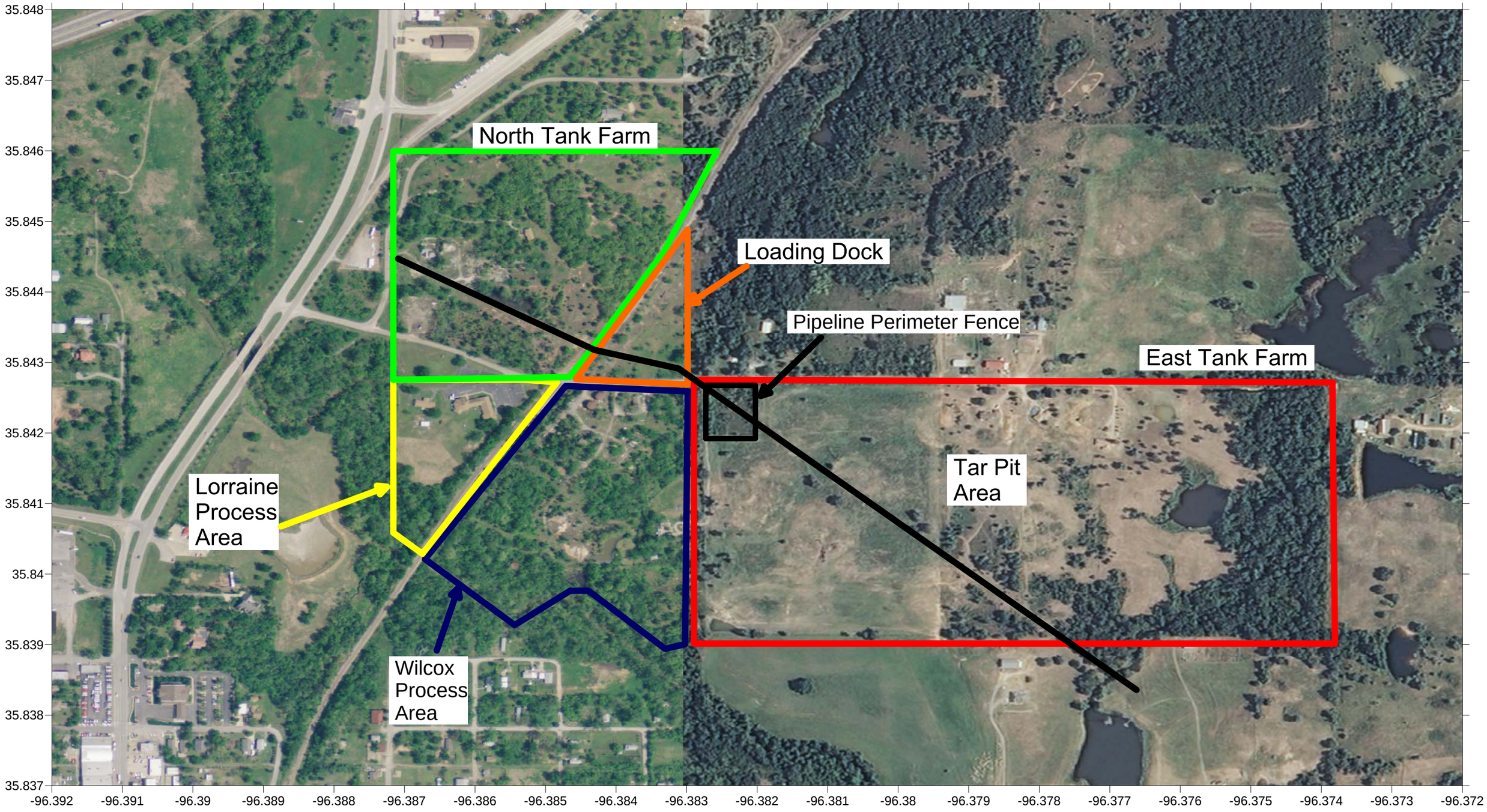
Figure 70 shows the location, directions of travel, and profile identifier of the GPR files collected in the Lorraine Process Area. Locations of anomalies detected by the GPR that are not interpreted to be bedrock are shown on Figure 70. Example profiles are presented in Figure 71.

Figure 72 presents the color-contour interval map of the interpreted bedrock elevation and Figure 73 includes the interpreted soil thickness. Based on the interpretation of the GPR data, the elevation of the top of the bedrock ranges from 778 to 804 feet AMSL. The soil thickness map shows the thickness of the soil to range from 7.5 to greater than 10 feet.

SUMMARY

The objective of the geophysical survey was to develop a site wide map of the bedrock elevation contours and the depth to bedrock contours. Figure 74 depicts the site wide bedrock surface elevations. In general the bedrock surface contours follow the ground surface contours.

Figure 75 is the interpreted soil thickness map across the site. Soil thicknesses range from the ground surface to approximately 15 feet. Most commonly, the soil thickness is approximately 8 to 10 feet. There are a few small isolated areas of thicker soil, but the geophysical data does not indicate the presence of wide spread areas of thick soil.



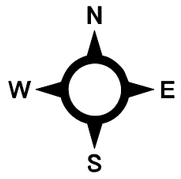
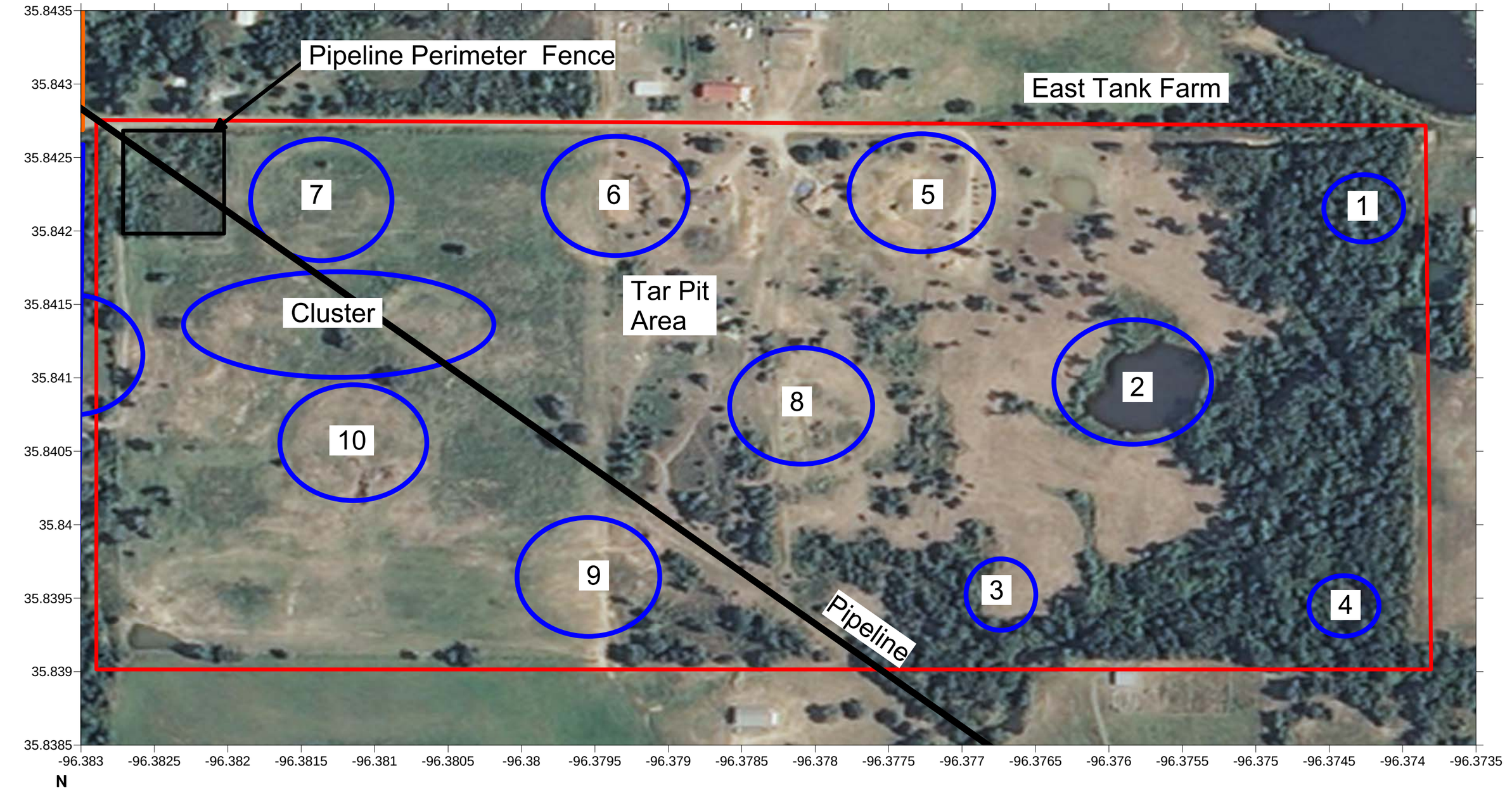


Figure 1
Overview of Wilcox and Lorraine Refineries Site

Coordinates are presented in Latitude/Longitude



Coordinates are presented in Latitude/Longitude

Figure 2
East Tank Farm Investigation Areas

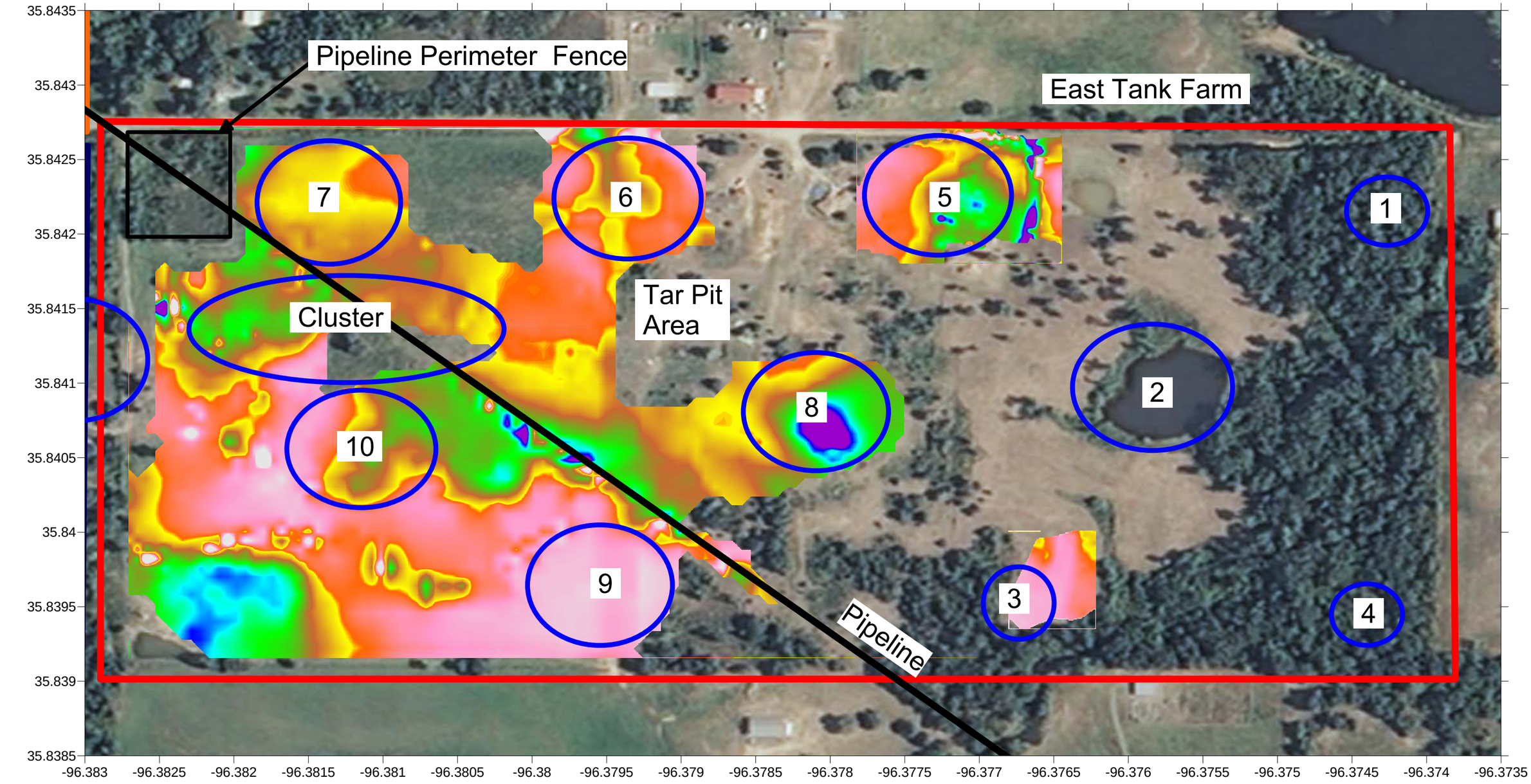
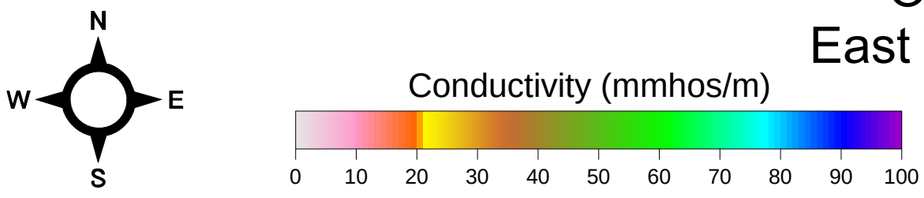


Figure 3
Overview EM31 Conductivity
East Tank Farm Investigation Areas



Coordinates are presented in Latitude/Longitude

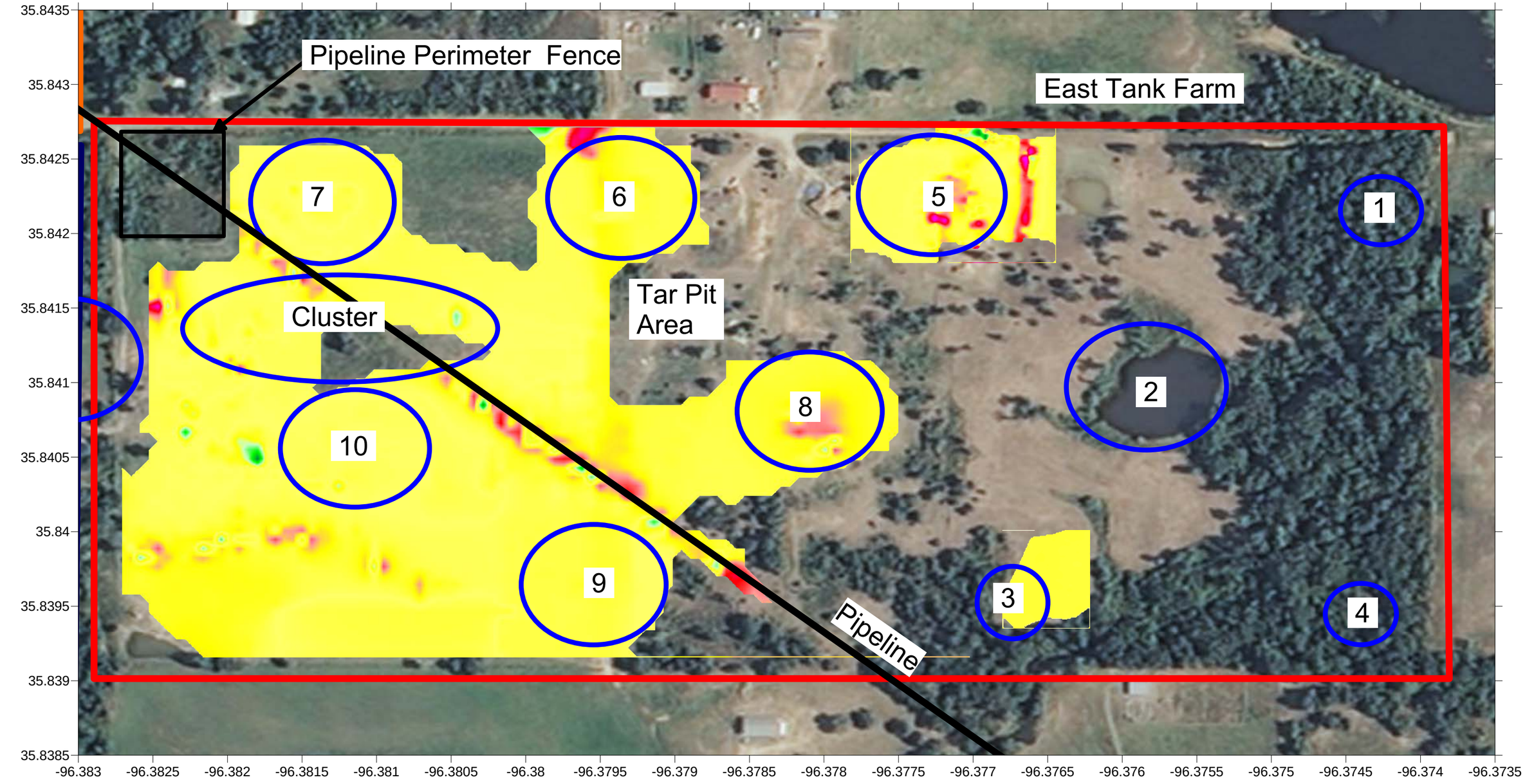


Figure 4
Overview of EM31 Inphase
East Tank Farm Investigation Areas

N
W
E
S

Inphase (ppt)

-20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20

Coordinates are presented in Latitude/Longitude

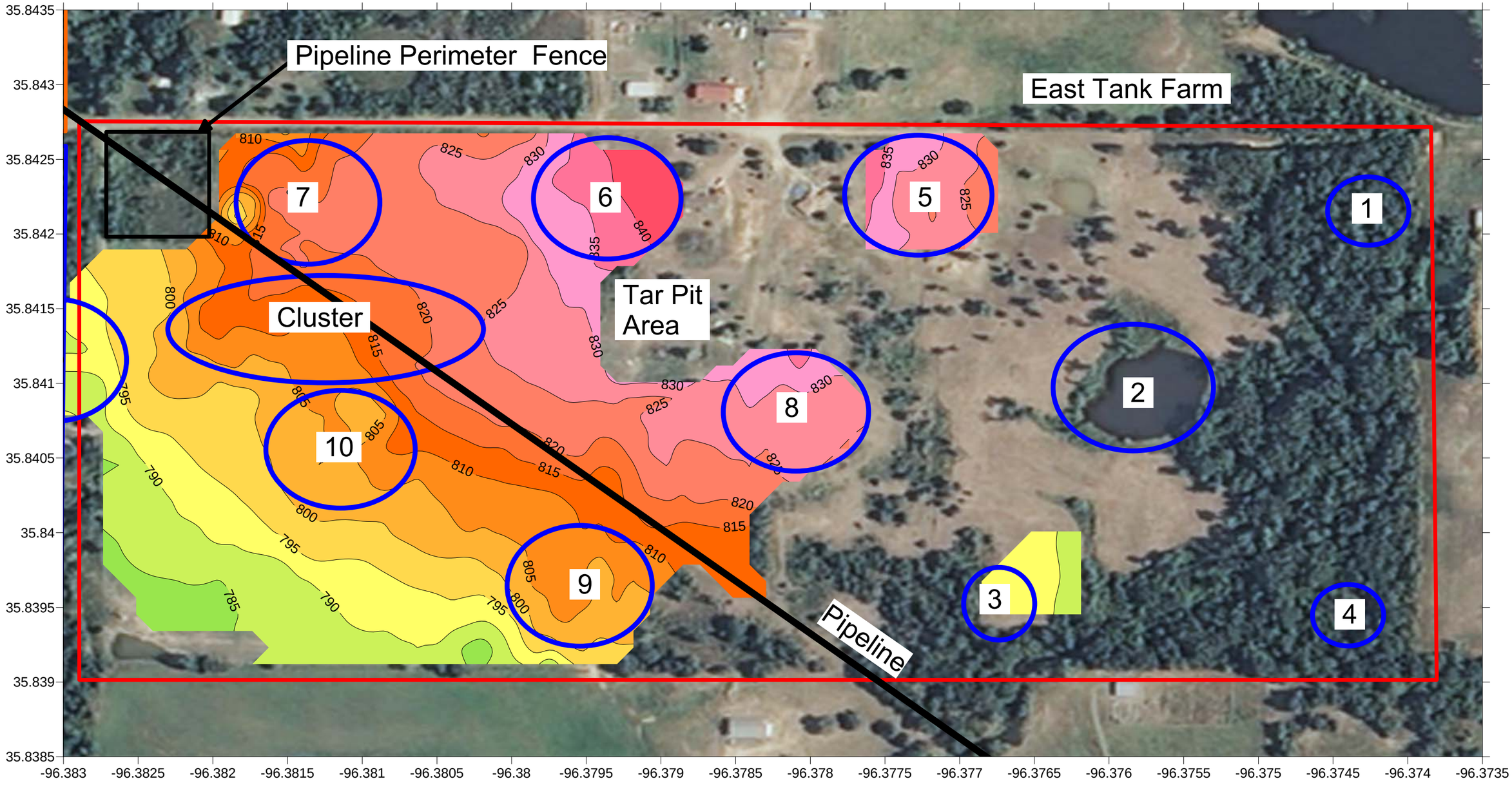
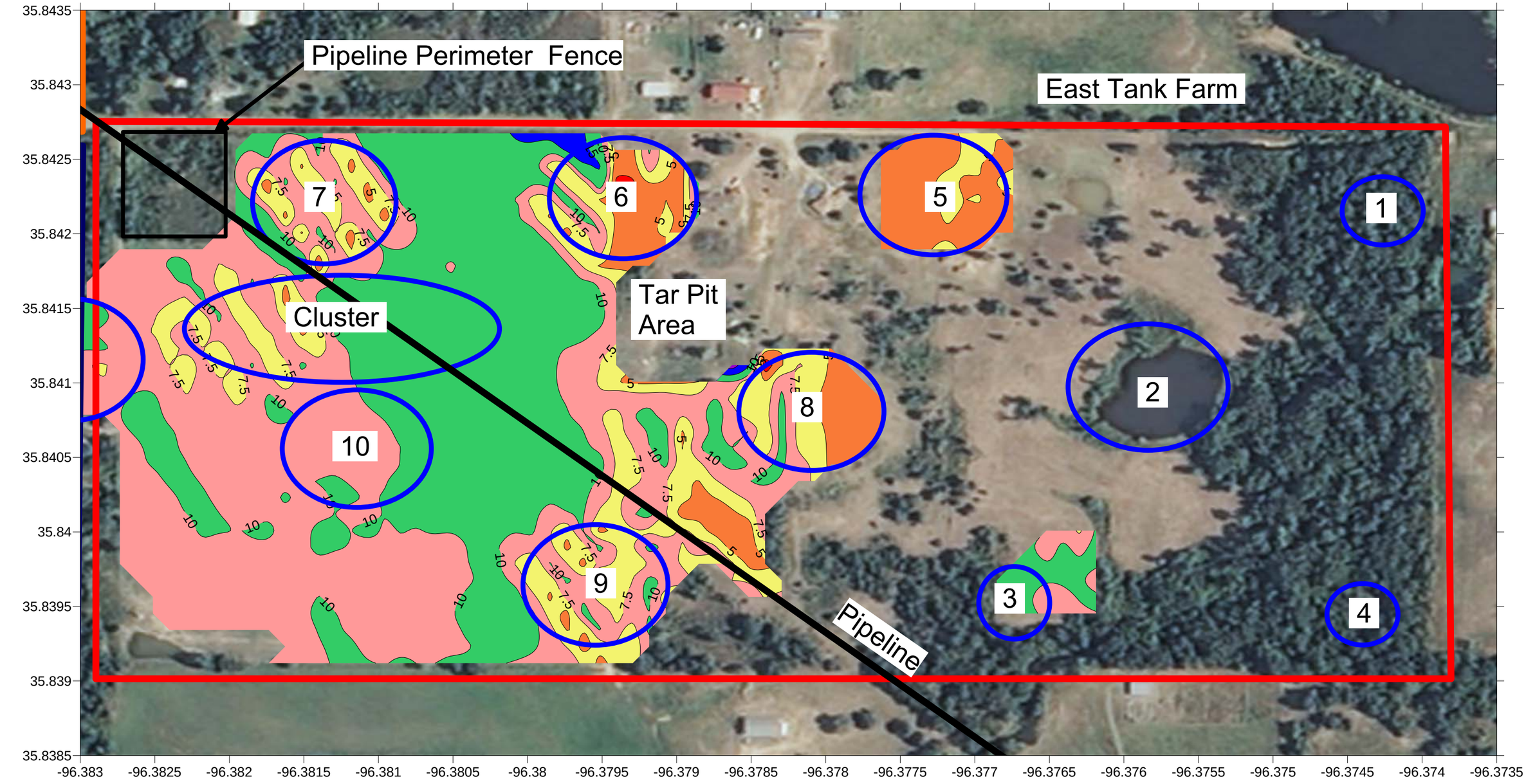


Figure 5
Bedrock Elevations
Overview of East Tank Farm

Coordinates are presented in Latitude/Longitude



N
W E
S

Coordinates are presented in Latitude/Longitude

Figure 6
Soil Thickness
Overview of East Tank Farm

Soil Thickness (Feet)

0 2.5 5 7.5 10 15 20

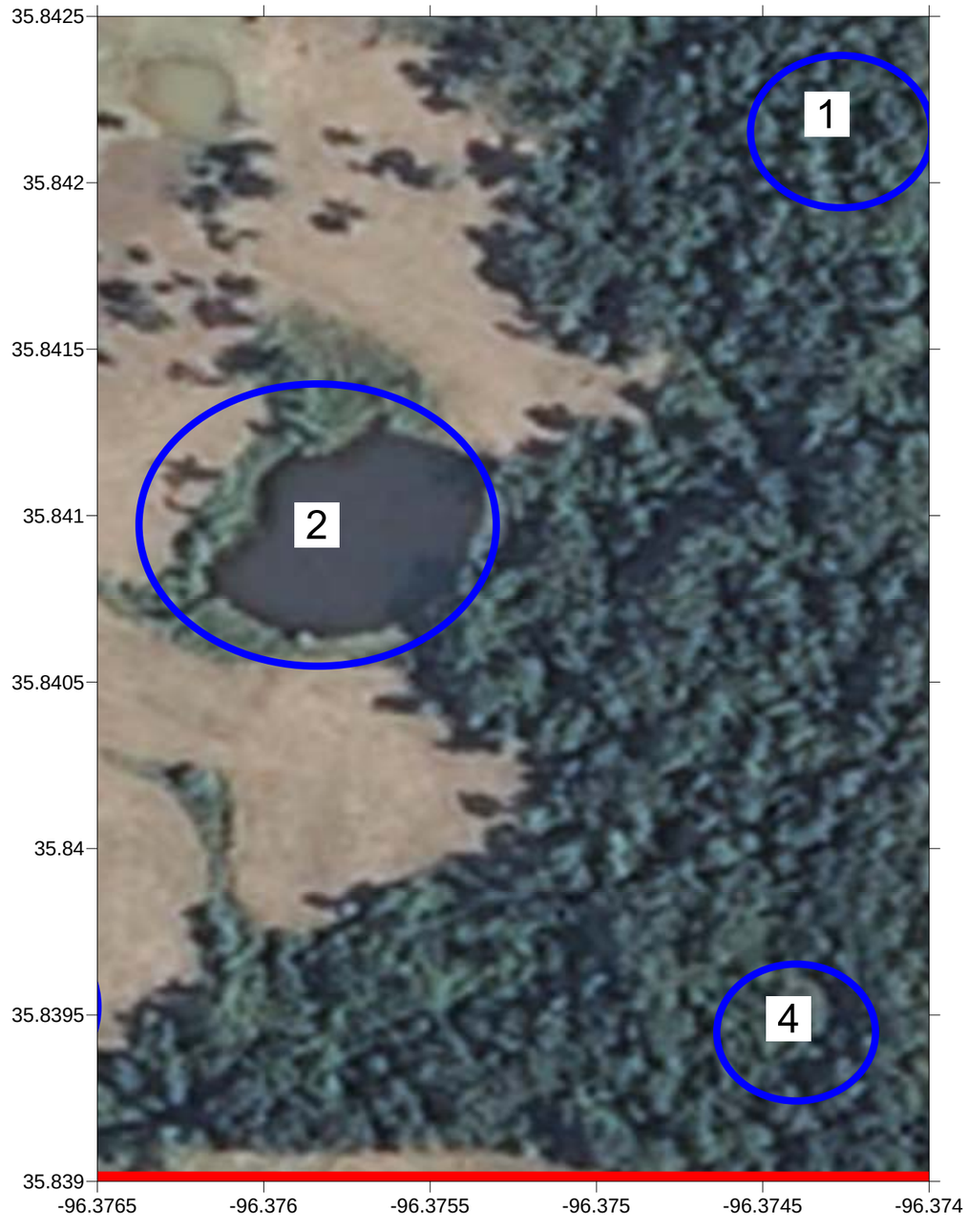
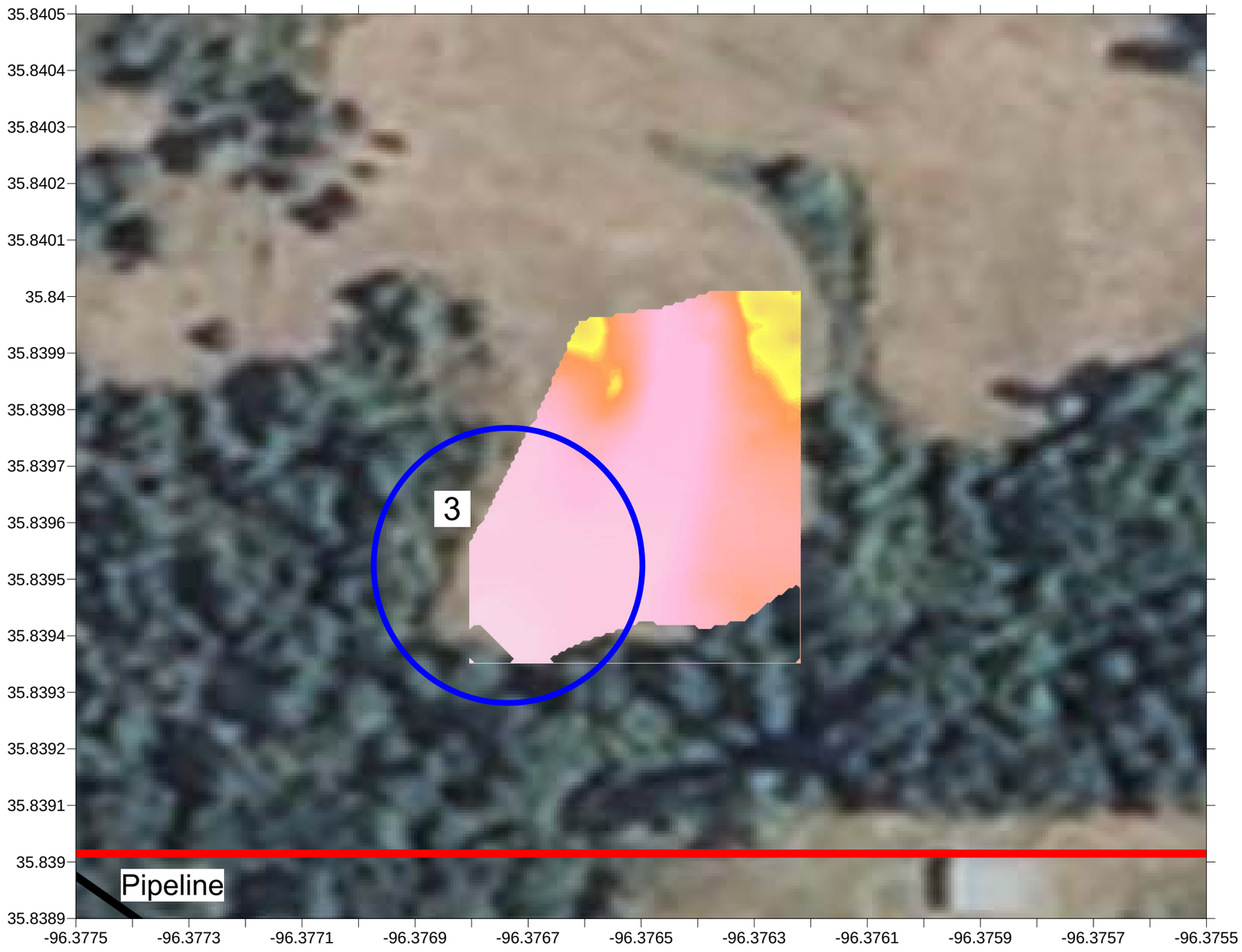
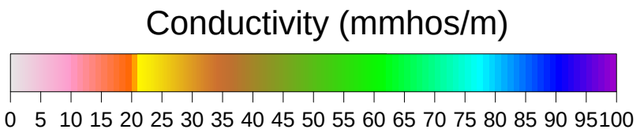


Figure 7
Investigation Areas Not Surveyed
East Tank Farm

N
W
E
S

Coordinates are presented in Latitude/Longitude





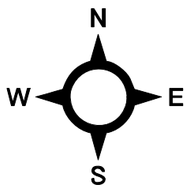
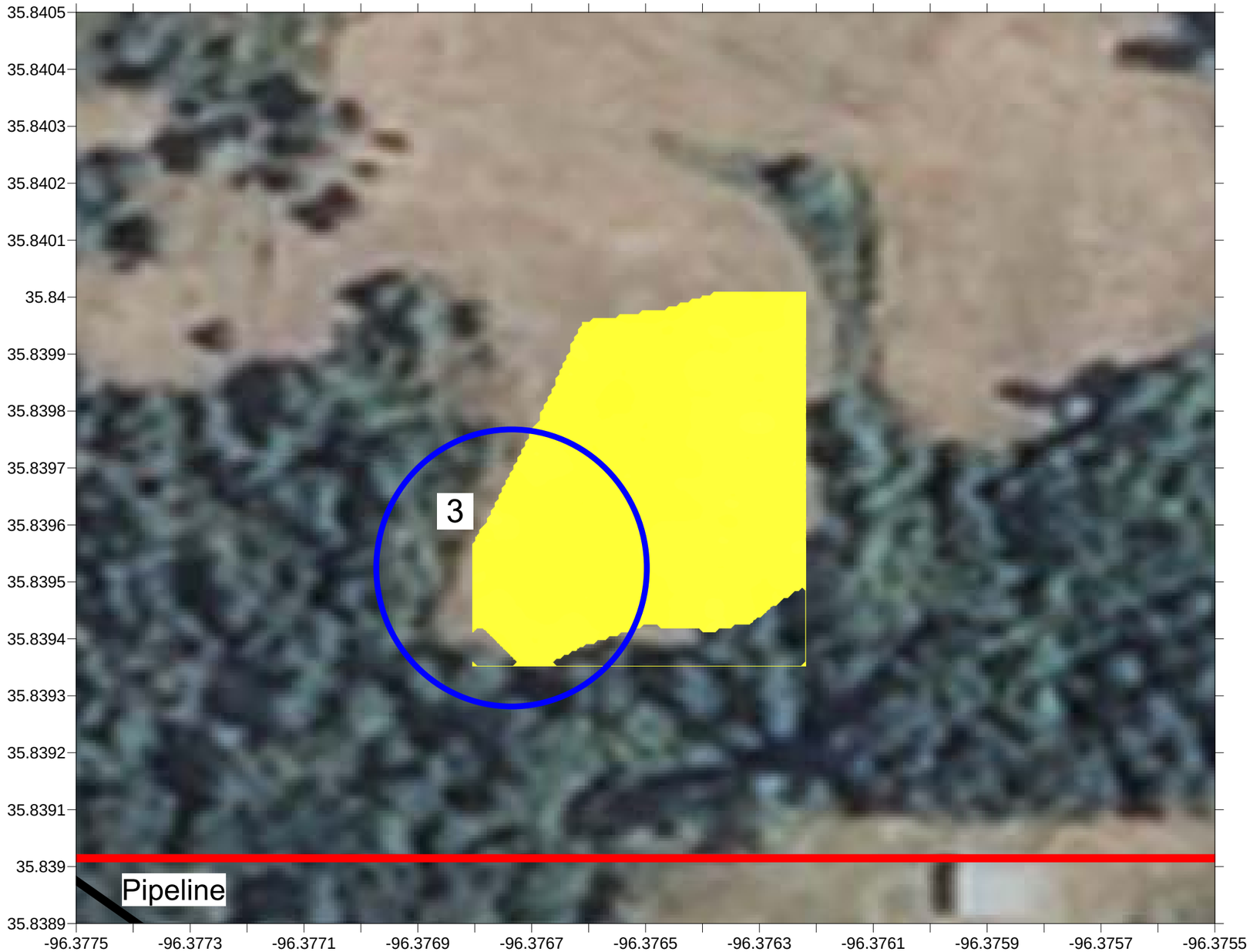
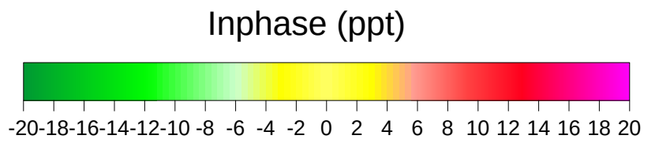


Figure 8
EM31 Conductivity Results
Investigation Area 3

Coordinates are presented in Latitude/Longitude





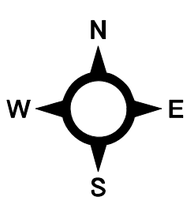
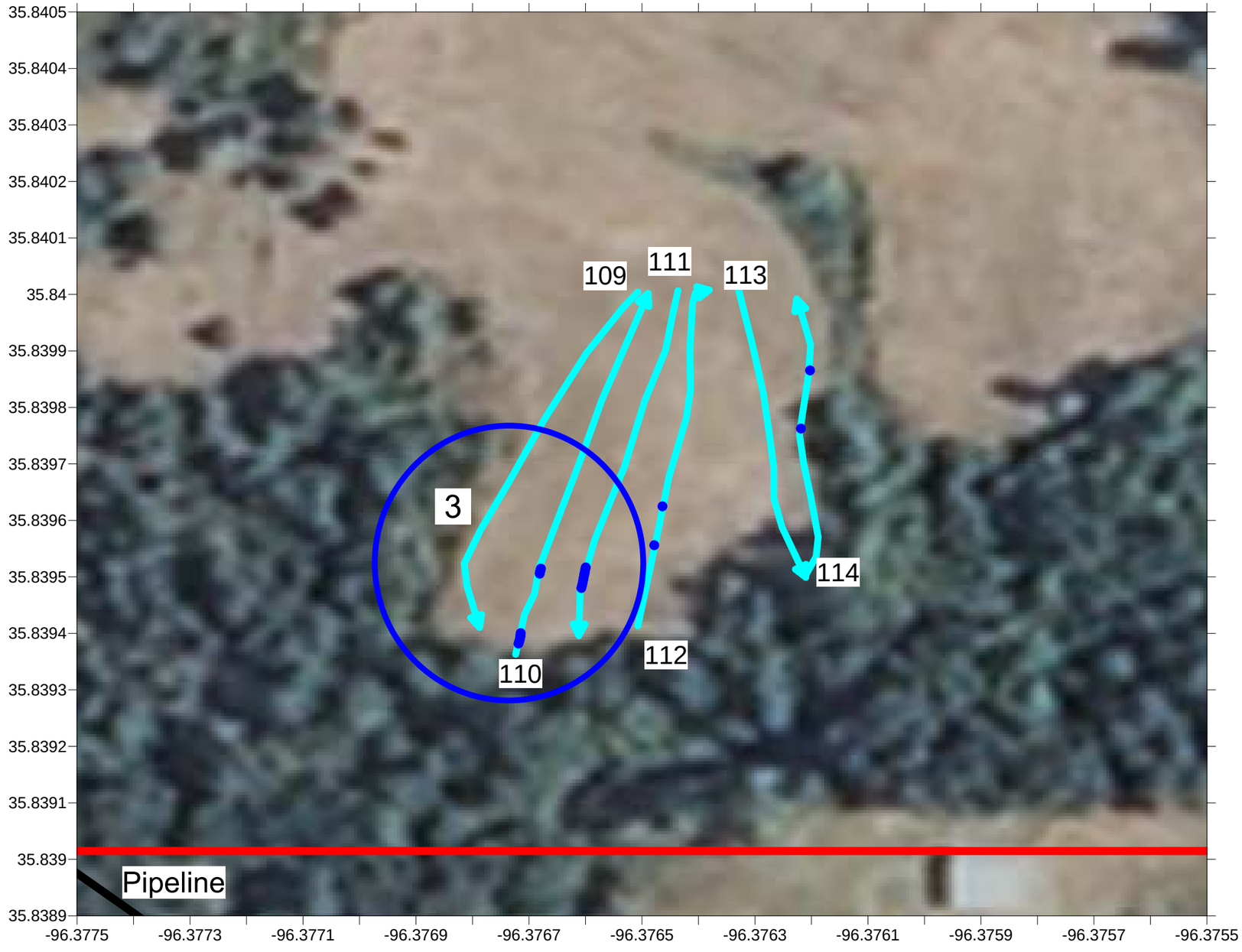


Figure 9
EM31 Inphase Results
Investigation Area 3

Coordinates are presented in Latitude/Longitude



N
W
E
S

Figure 10
Location of GPR Traverses and Anomalies
Investigation Area 3

Coordinates are presented in Latitude/Longitude

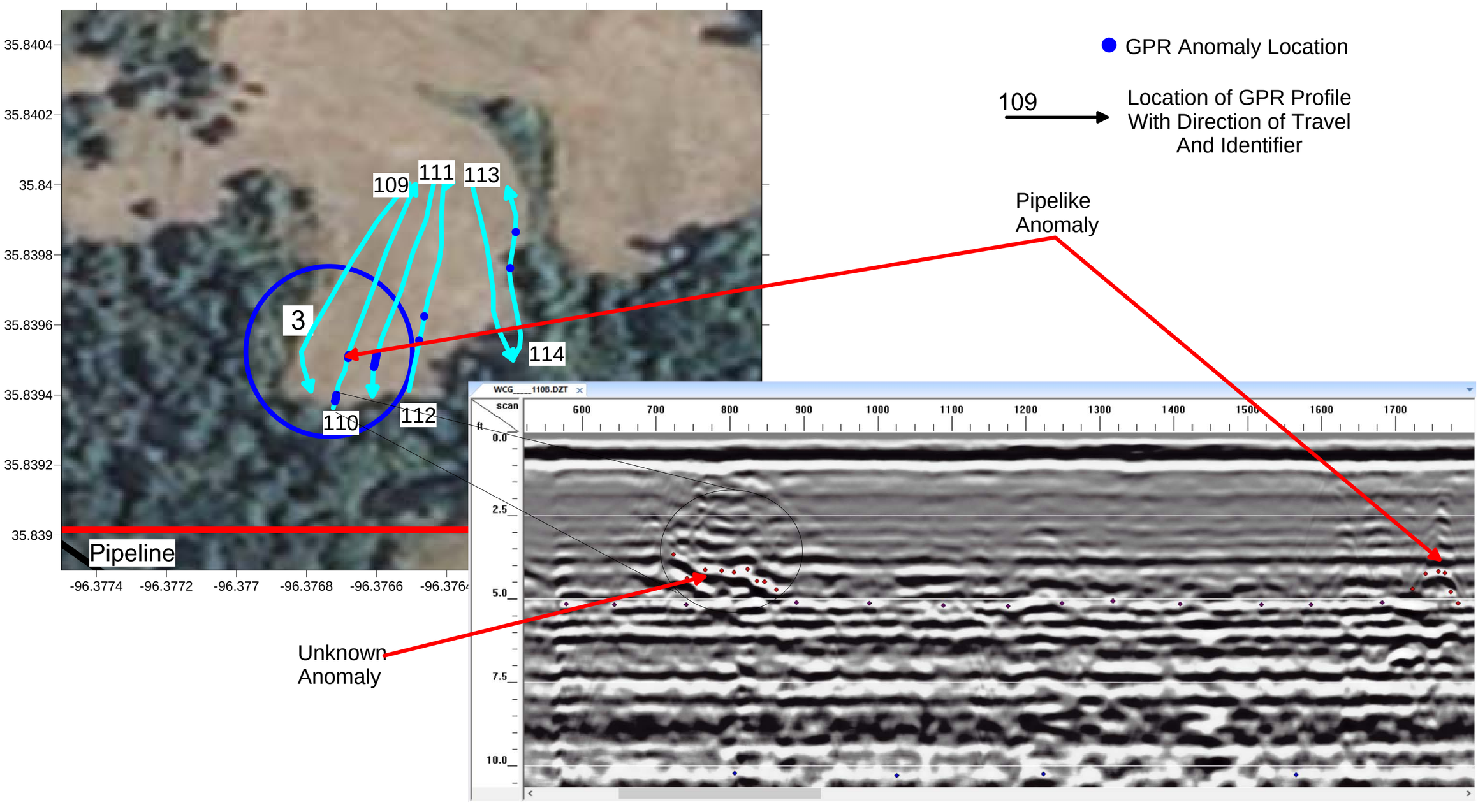
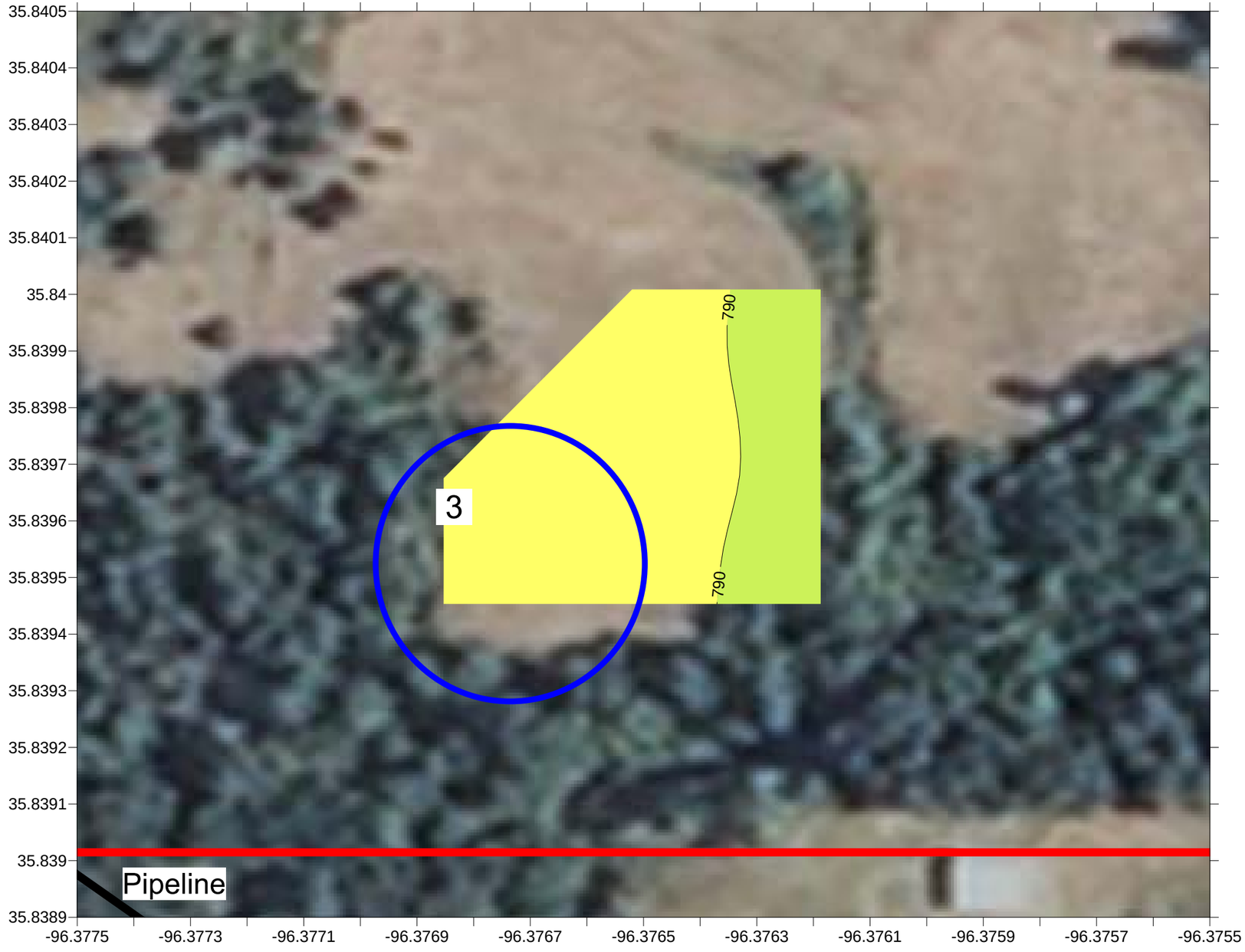


Figure 11
GPR Profiles
Investigation Area 3

Coordinates are presented in Latitude/Longitude



Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

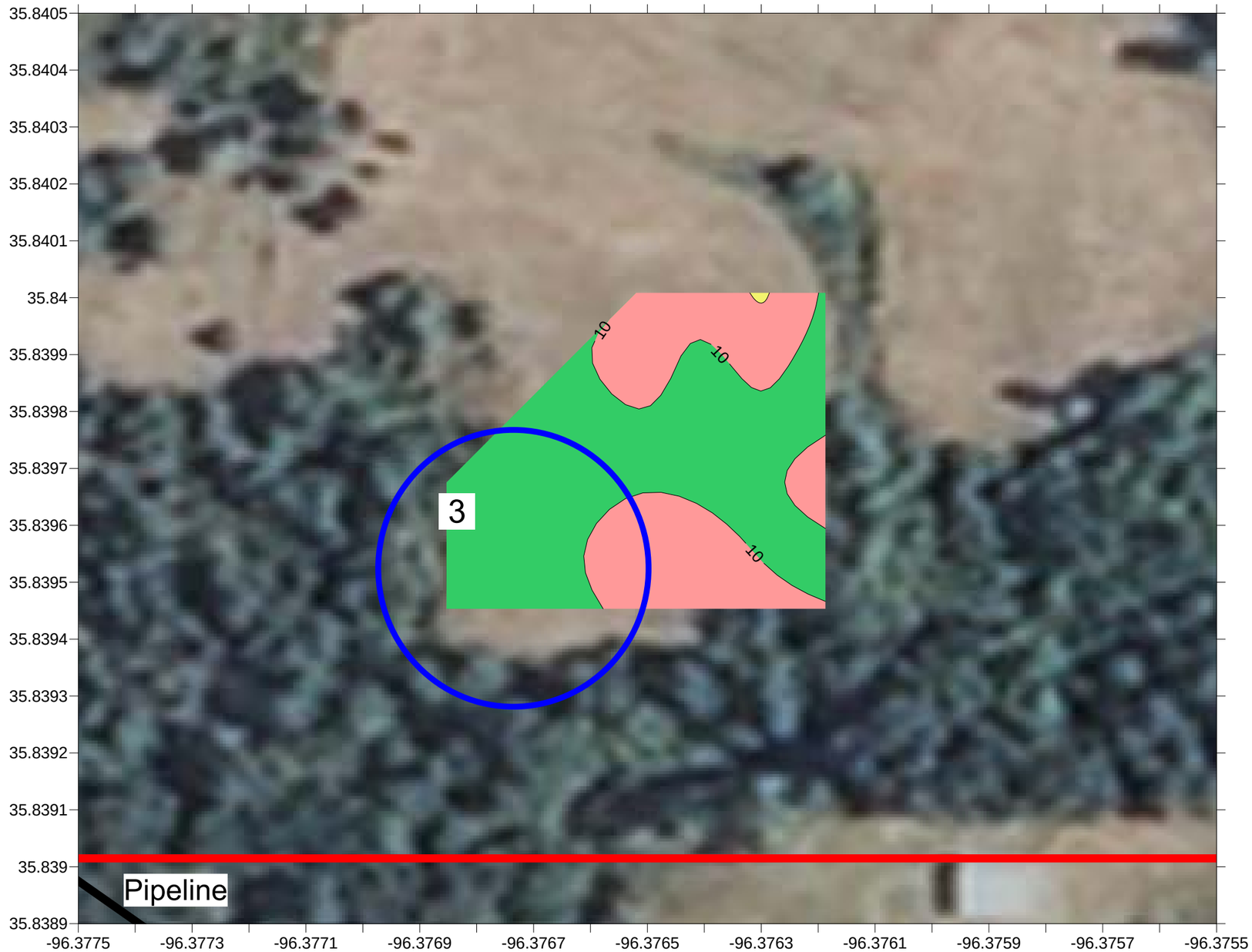
N

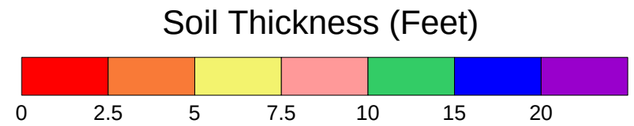
W E

S

Figure 12
Bedrock Elevation
Investigation Area 3

Coordinates are presented in Latitude/Longitude





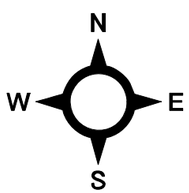
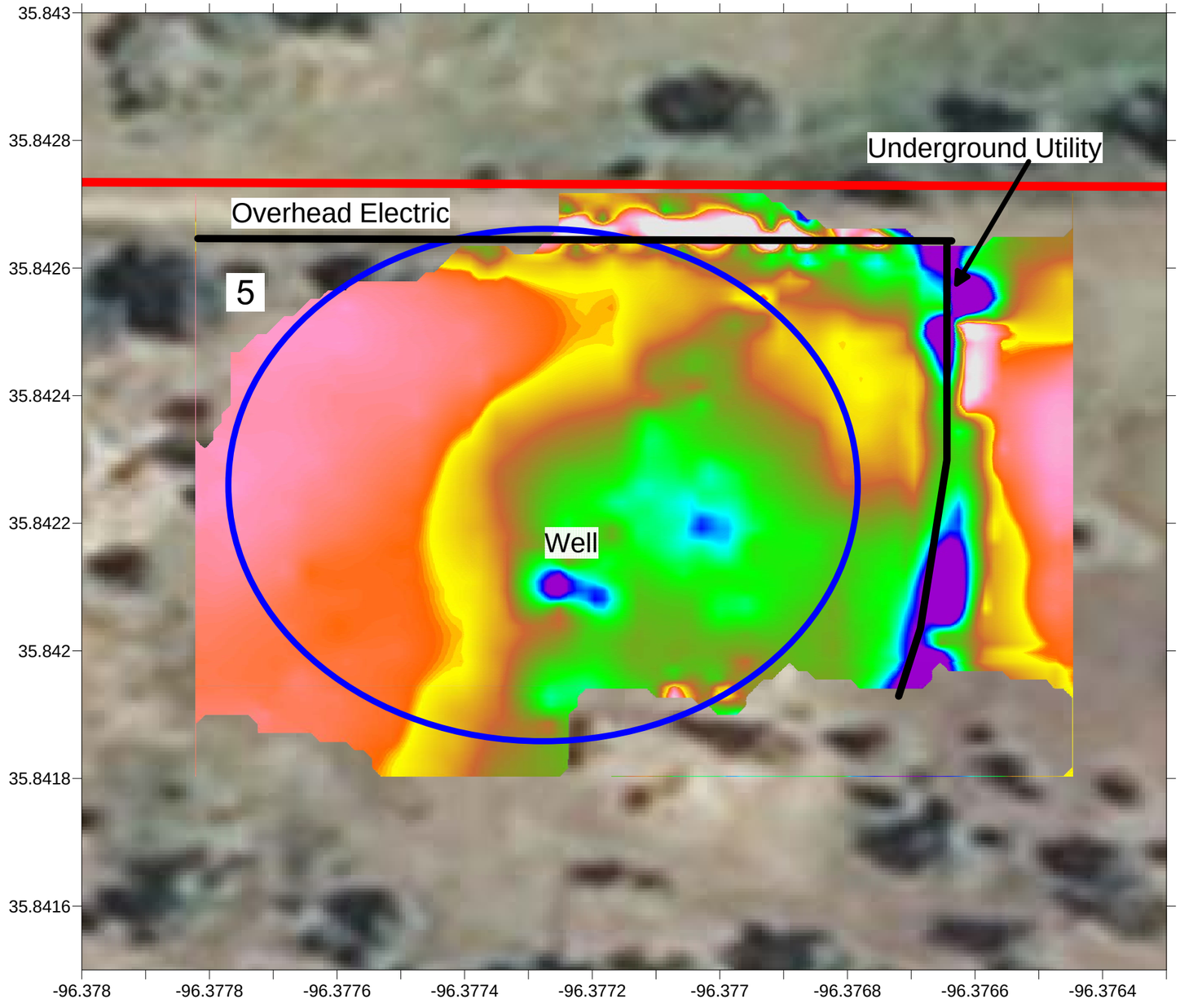
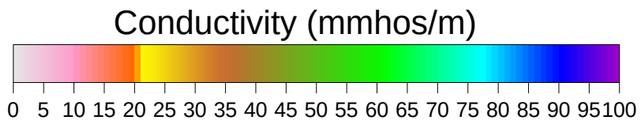


Figure 13
Soil Thickness
Investigation Area 3

Coordinates are presented in Latitude/Longitude





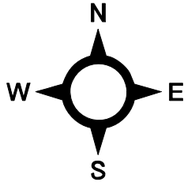
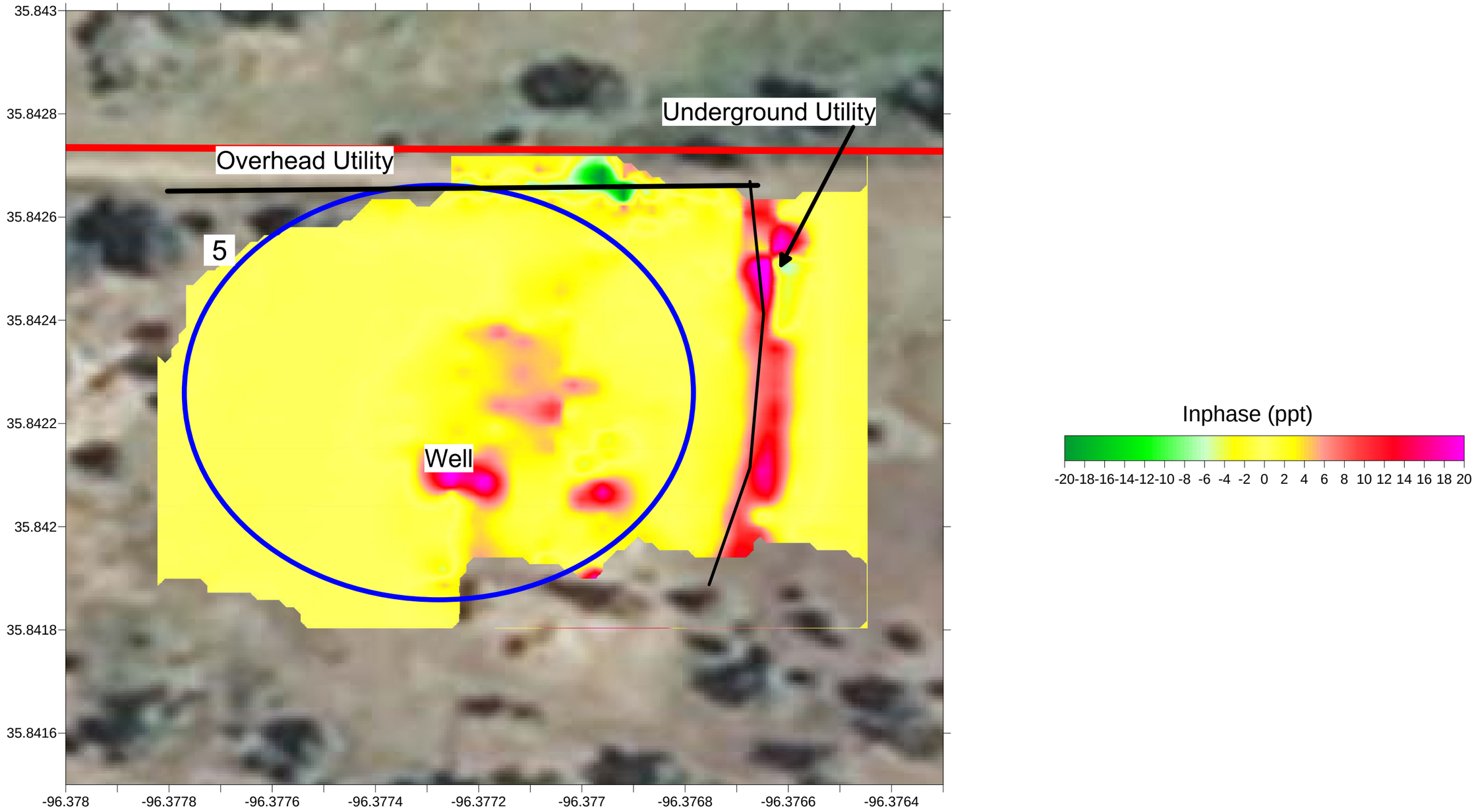


Figure 14
EM31 Conductivity Results
Investigation Area 5

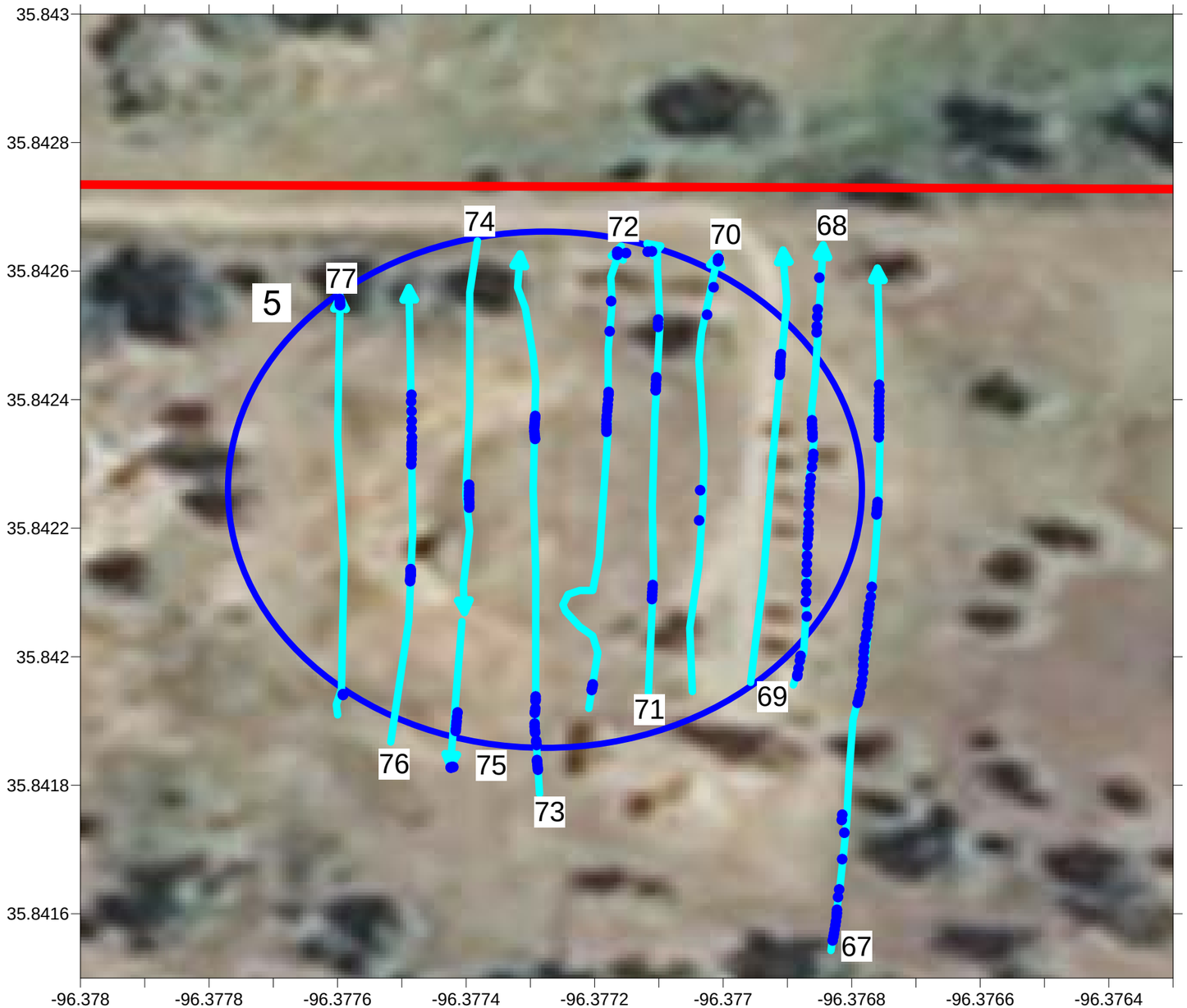
Coordinates are presented in Latitude/Longitude



N
W E
S

Figure 15
EM31 Inphase Results
Investigation Area 5

Coordinates are presented in Latitude/Longitude



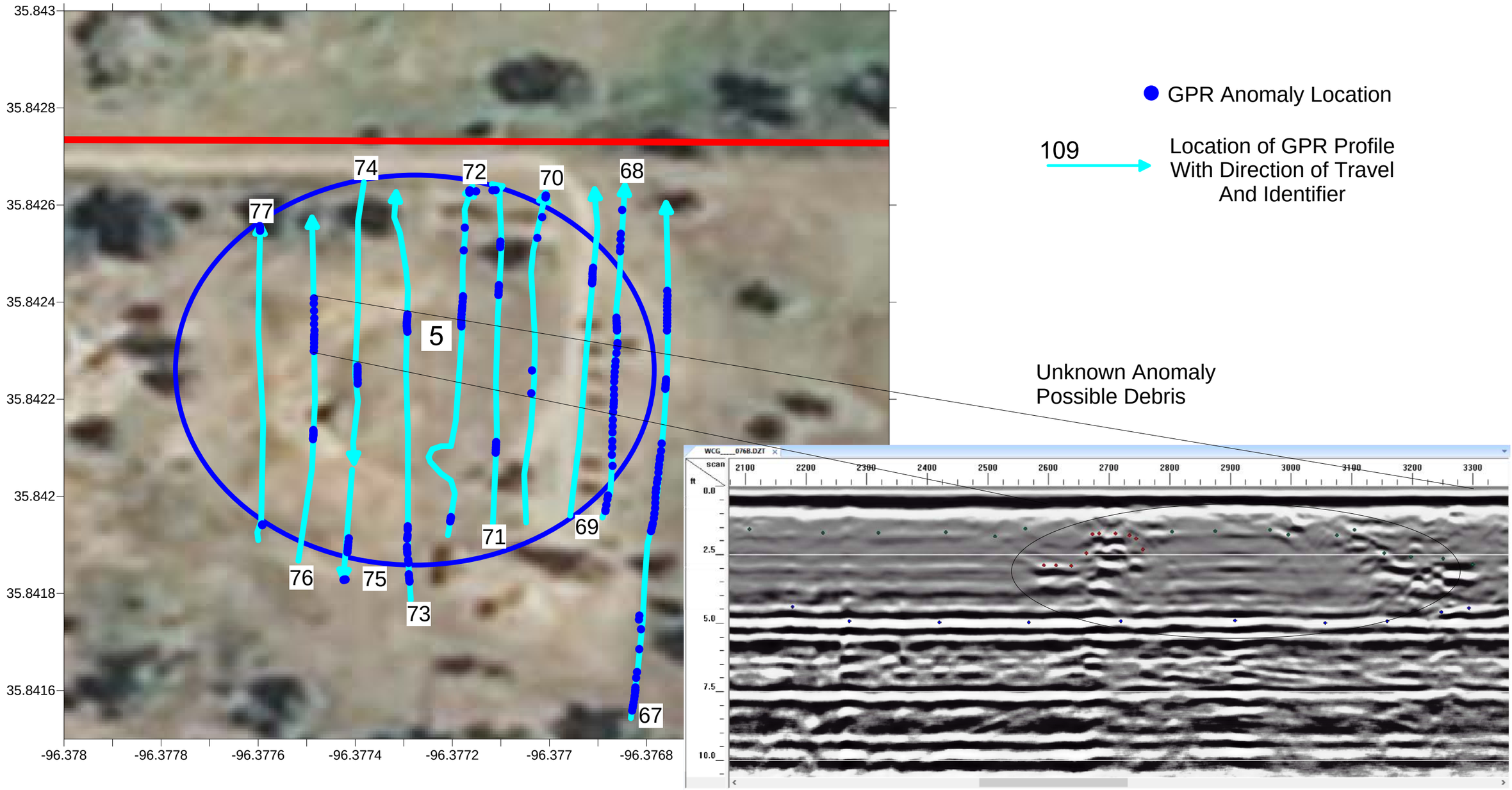
GPR Anomaly Location

109 → Location of GPR Profile With Direction of Travel And Identifier

N
W E
S

Figure 16
Location of GPR Profiles and Anomalies
Investigation Area 5

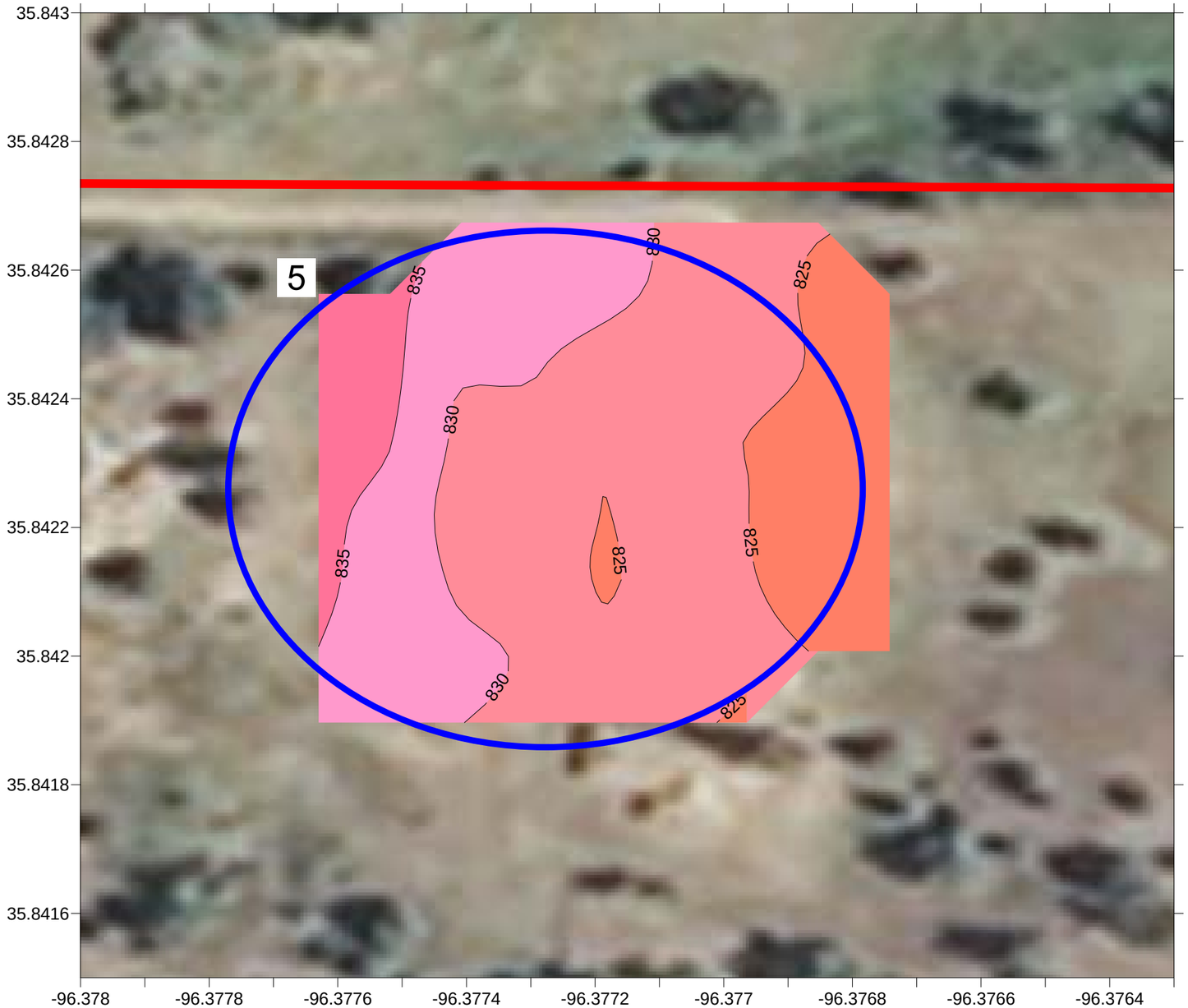
Coordinates are presented in Latitude/Longitude



N
W
E
S

Figure 17
GPR Profiles
Investigation Area 5

Coordinates are presented in Latitude/Longitude



Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

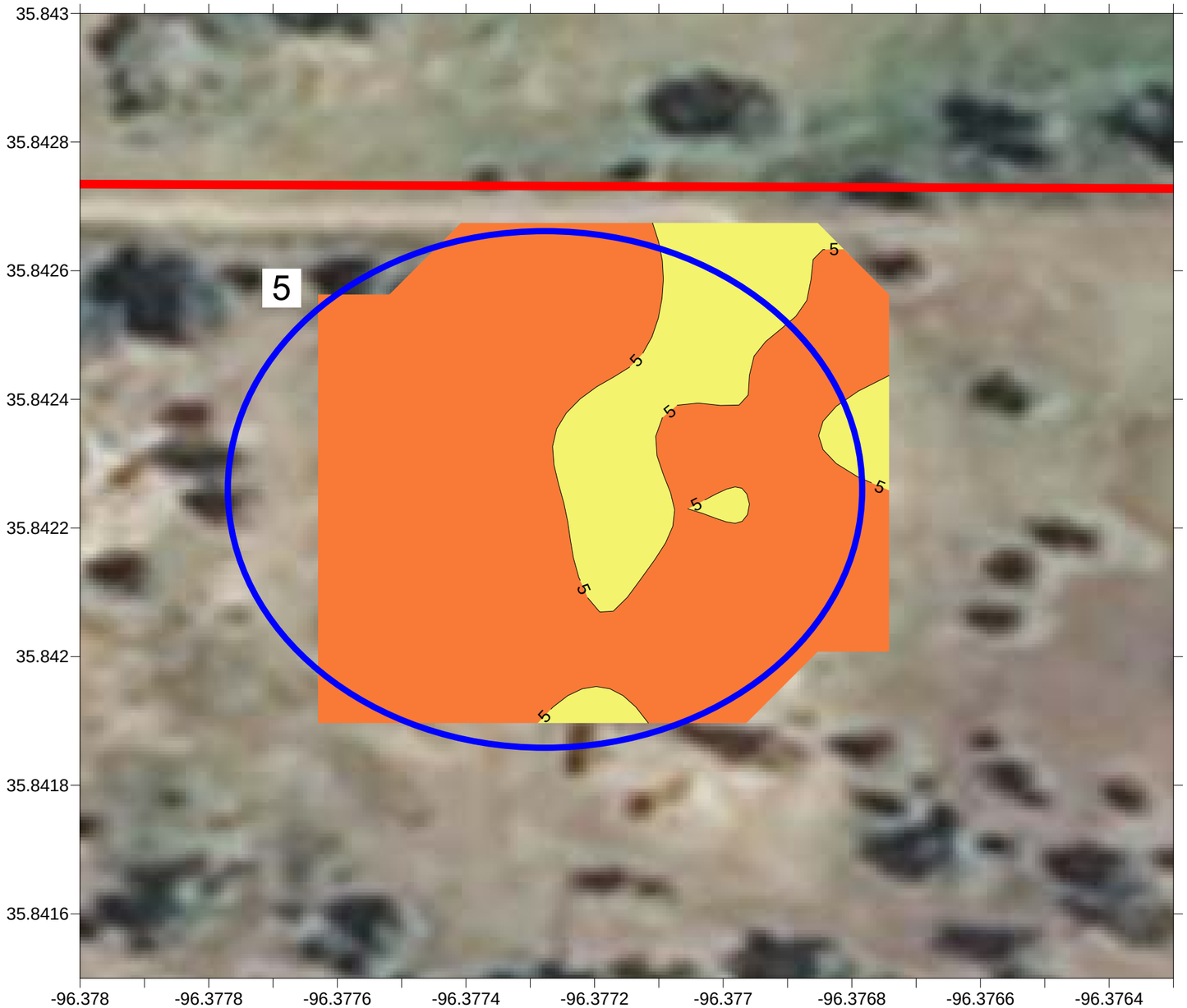
N

W E

S

Figure 18
Bedrock Elevation
Investigation Area 5

Coordinates are presented in Latitude/Longitude



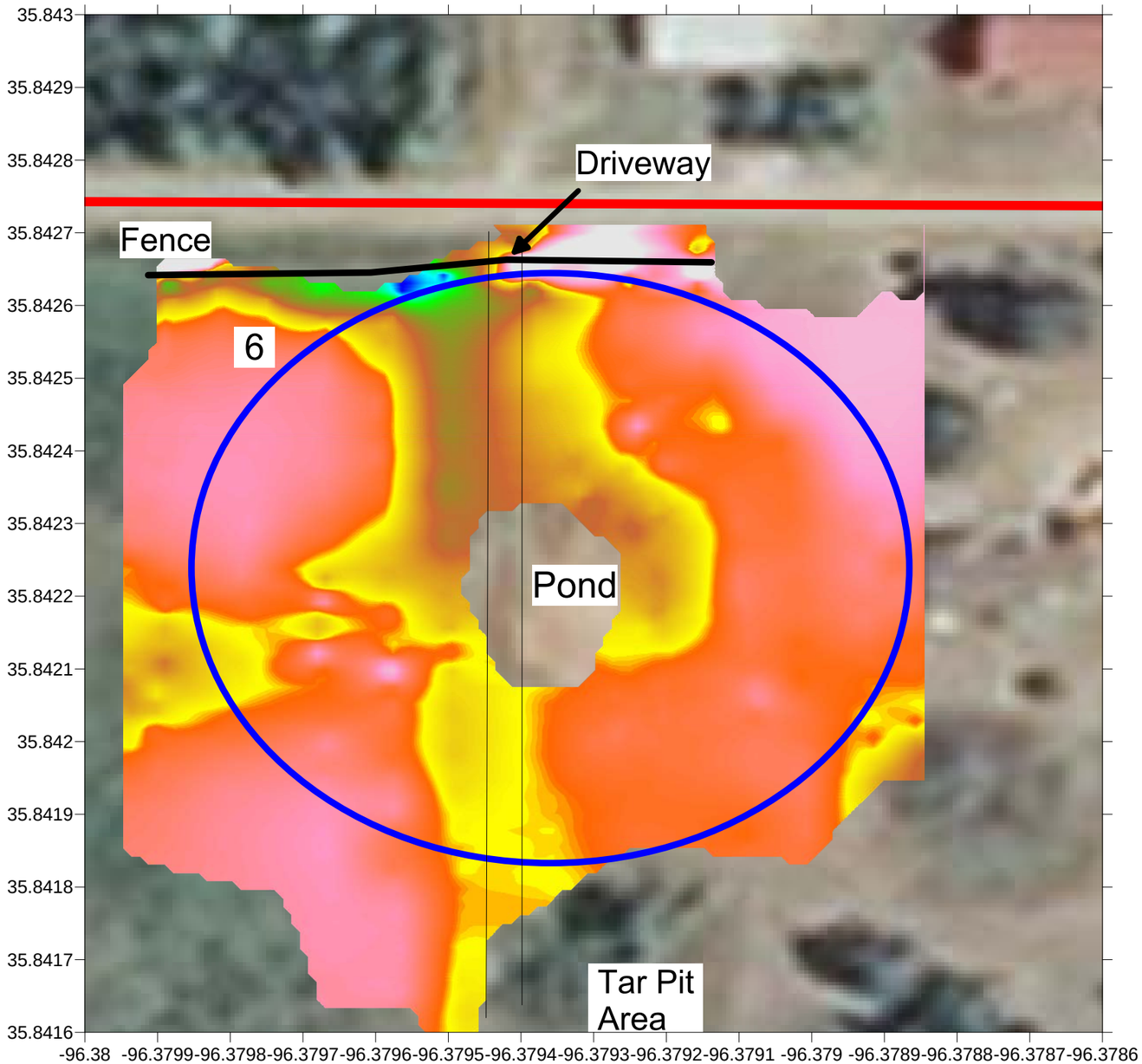
Soil Thickness (Feet)

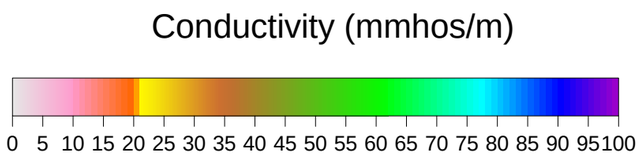
0 2.5 5 7.5 10 15 20

N
W E
S

Figure 19
Soil Thickness
Investigation Area 5

Coordinates are presented in Latitude/Longitude





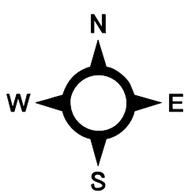
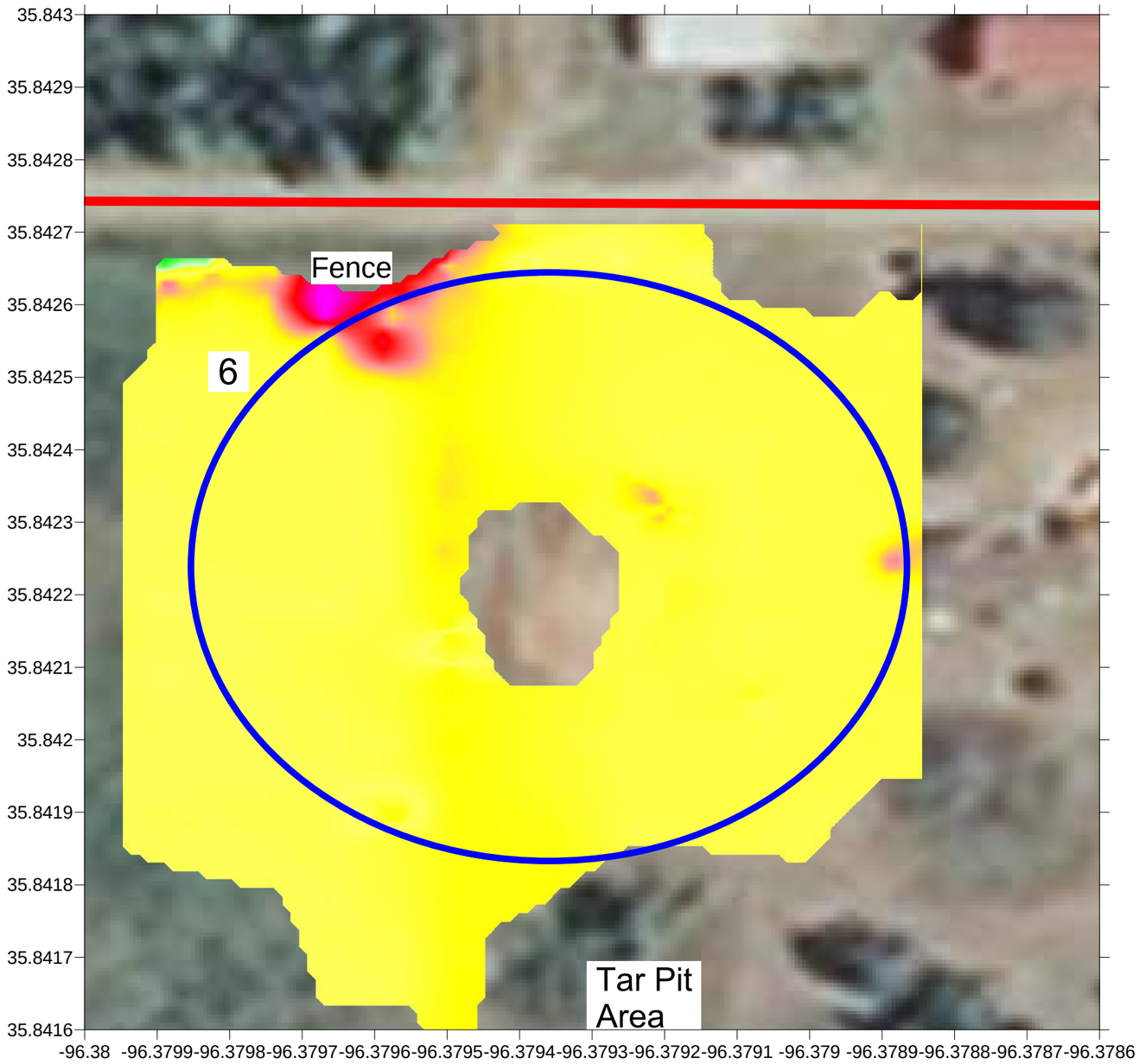
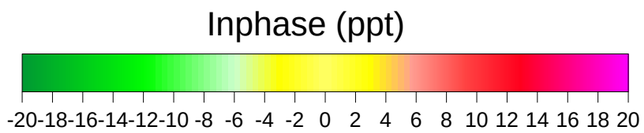


Figure 20
EM31 Conductivity Results
Investigation Area 6

Coordinates are presented in Latitude/Longitude





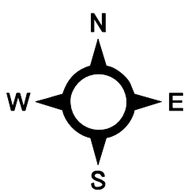
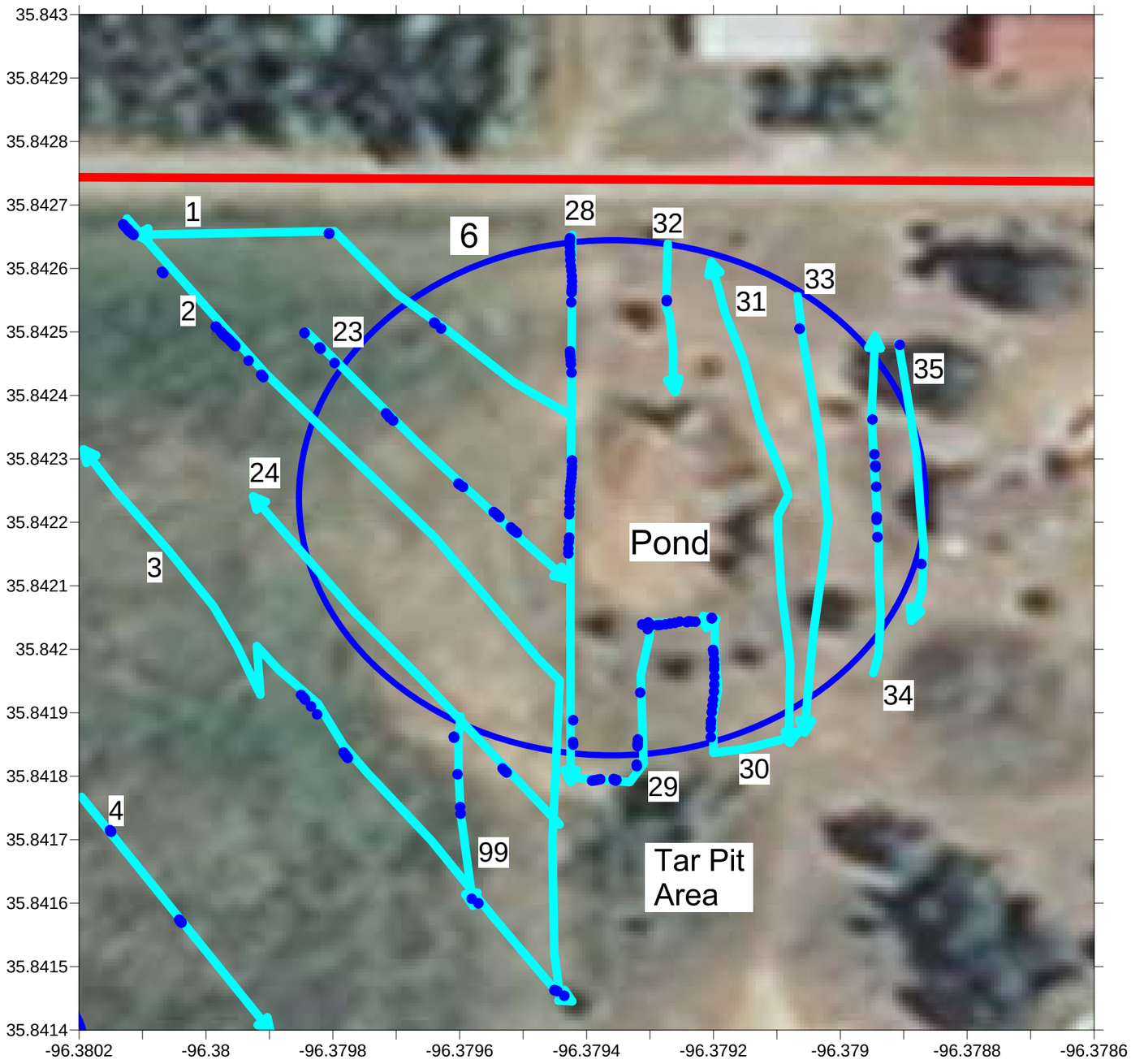


Figure 21
EM31 Inphase Results
Investigation Area 6

Coordinates are presented in Latitude/Longitude



GPR Anomaly Location

35 → Location of GPR Profile With Direction of Travel And Identifier

N
W E
S

Figure 22
Locations of GPR Traverses and Anomalies
Investigation Area 6

Coordinates are presented in Latitude/Longitude

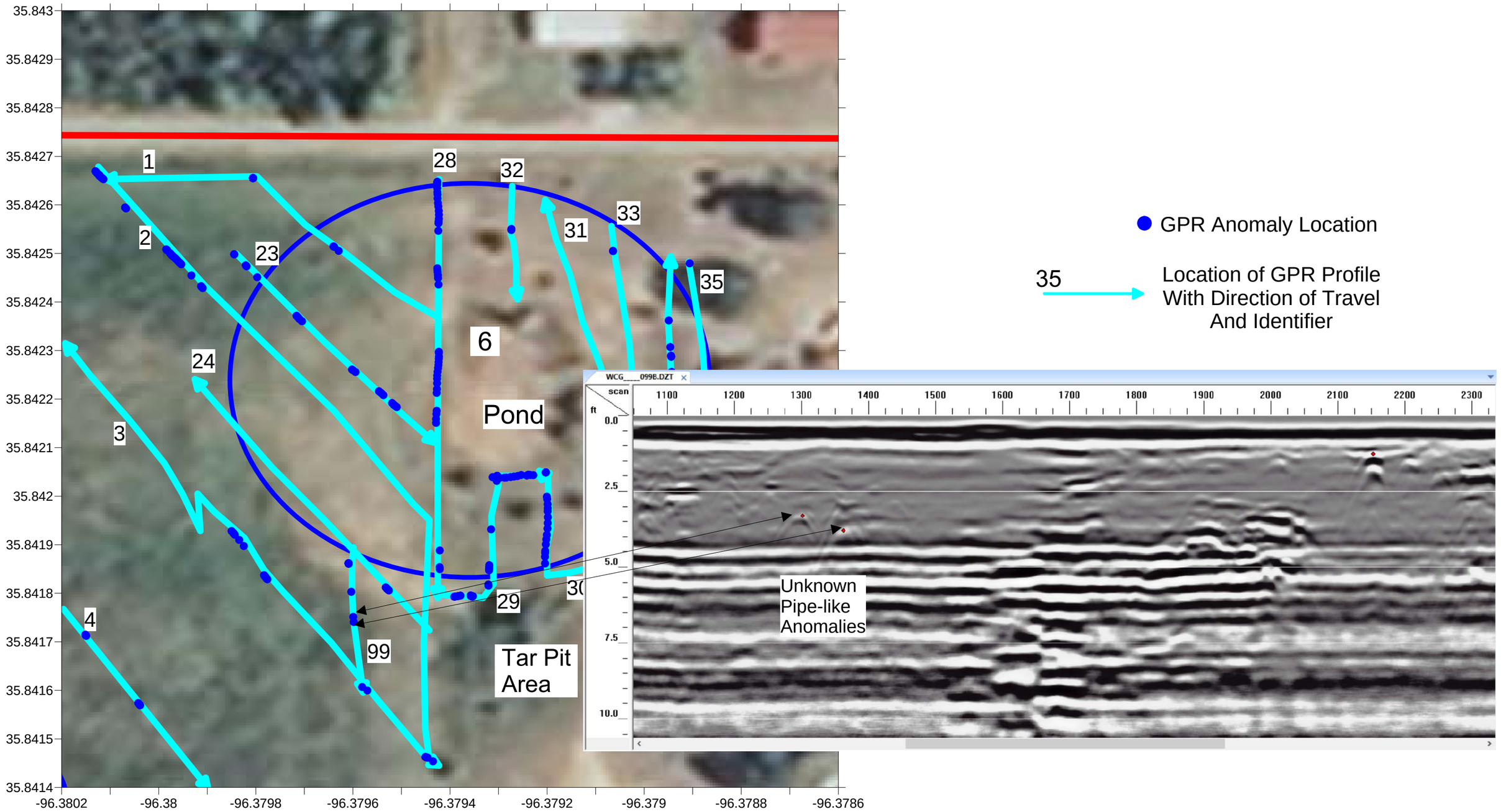
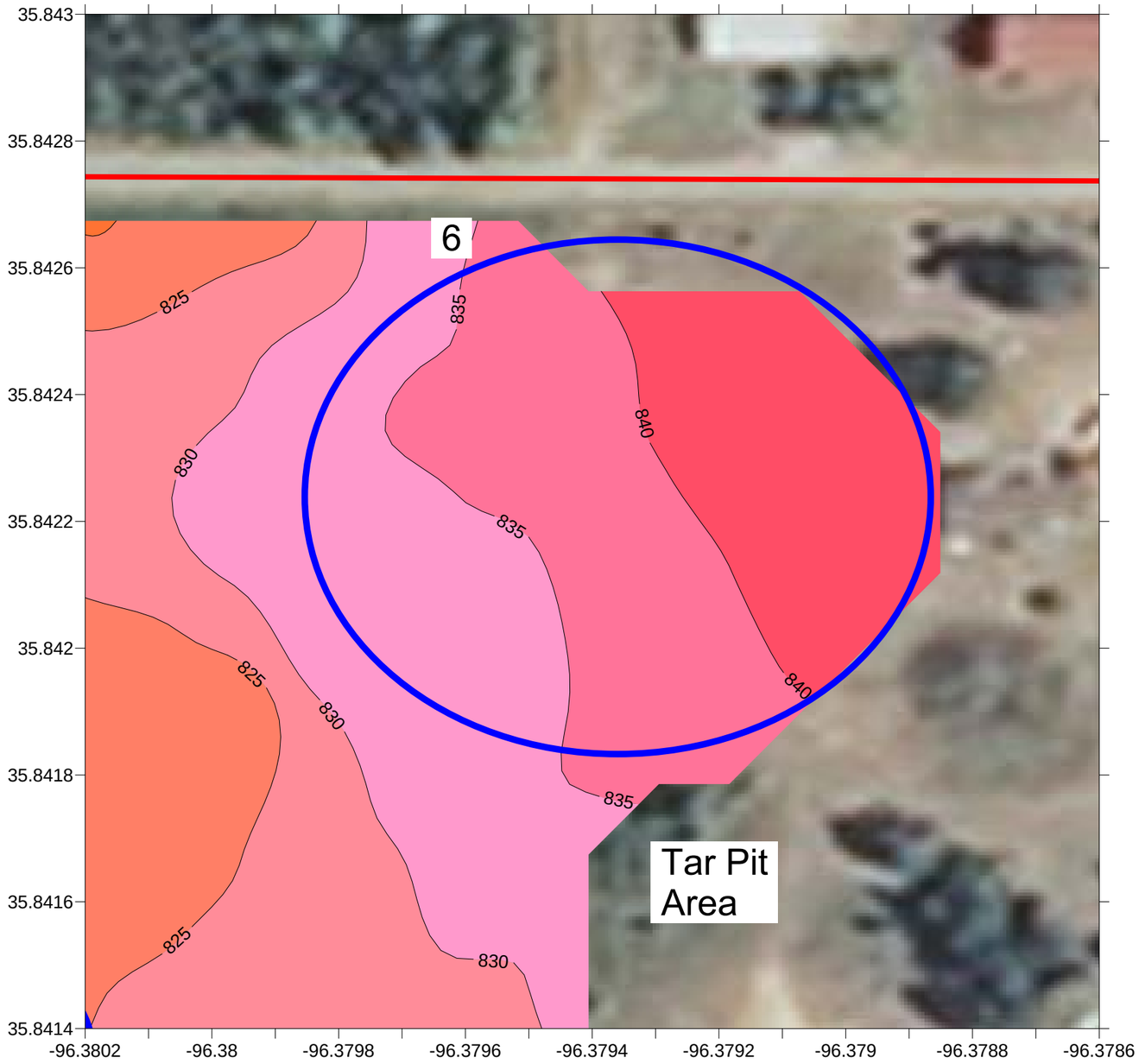


Figure 23
GPR Profiles
Investigation Area 6

Coordinates are presented in Latitude/Longitude



Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

N

W E

S

Figure 24
Bedrock Elevation
Investigation Area 6

Coordinates are presented in Latitude/Longitude

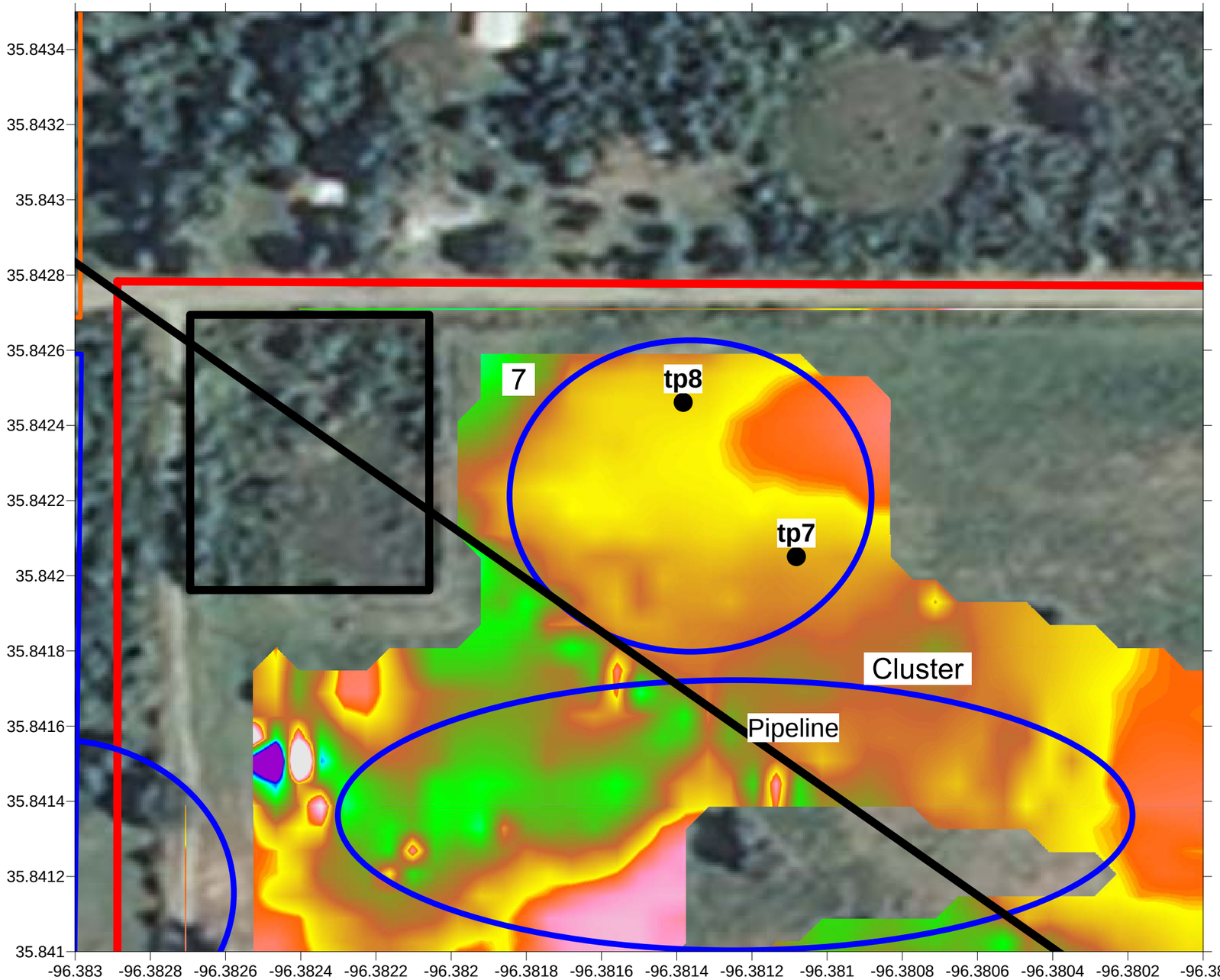
Soil Thickness (Feet)

0 2.5 5 7.5 10 15 20

N
W E
S

Figure 25
Soil Thickness
Investigation Area 6

Coordinates are presented in Latitude/Longitude



● Test Pit Location with Identifier

TP7
Bedrock depth greater than 5.5 feet

TP8
Bedrock depth greater than 7.4 feet

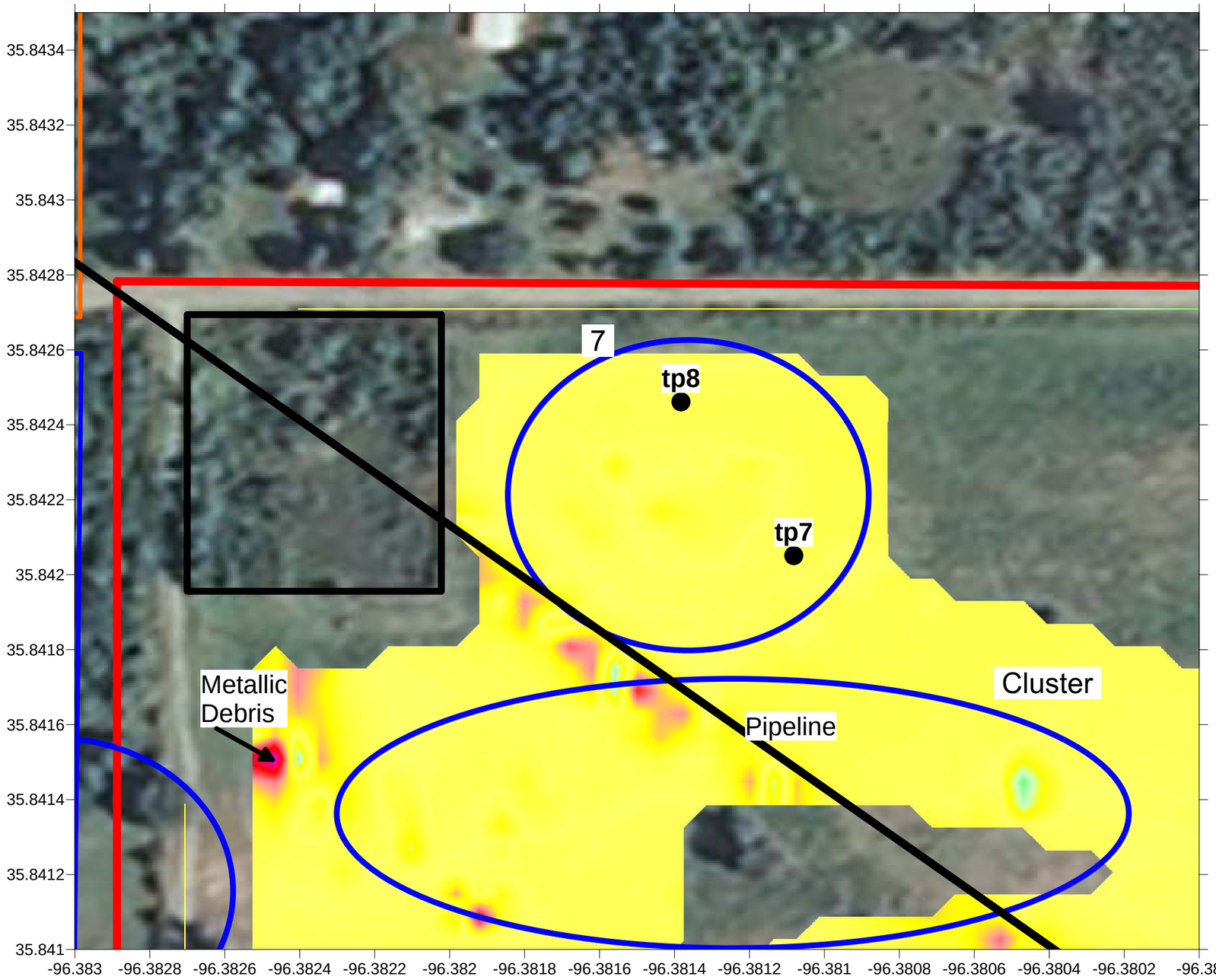
Conductivity (mmhos/m)

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

N
W E
S

Figure 26
EM31 Conductivity Results
Tank Cluster and Investigation Area 7

Coordinates are presented in Latitude/Longitude



● Test Pit Location with Identifier

TP7
Bedrock depth greater than 5.5 feet

TP8
Bedrock depth greater than 7.4 feet

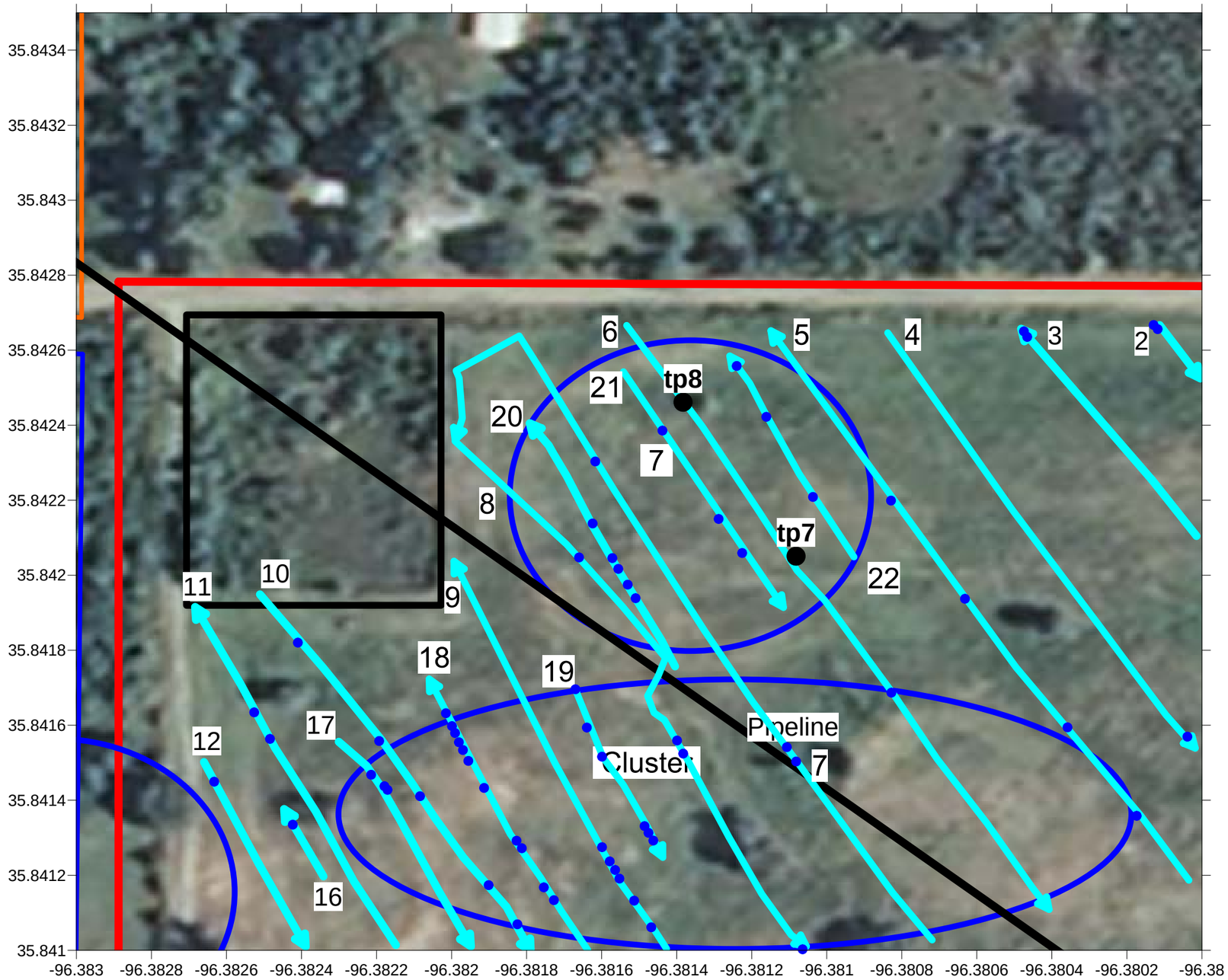
Inphase (ppt)

-20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20

N
W
E
S

Figure 27
EM31 Inphase Results
Tank Cluster and Investigation Area 7

Coordinates are presented in Latitude/Longitude



GPR Anomaly Location

6 → Location of GPR Profile With Direction of Travel And Identifier

● Test Pit Location with Identifier

TP7
Bedrock depth greater than 5.5 feet

TP8
Bedrock depth greater than 7.4 feet

N
W E
S

Figure 28
Location of GPR Traverses and Anomalies
Tank Cluster and Investigation Area 7

Coordinates are presented in Latitude/Longitude

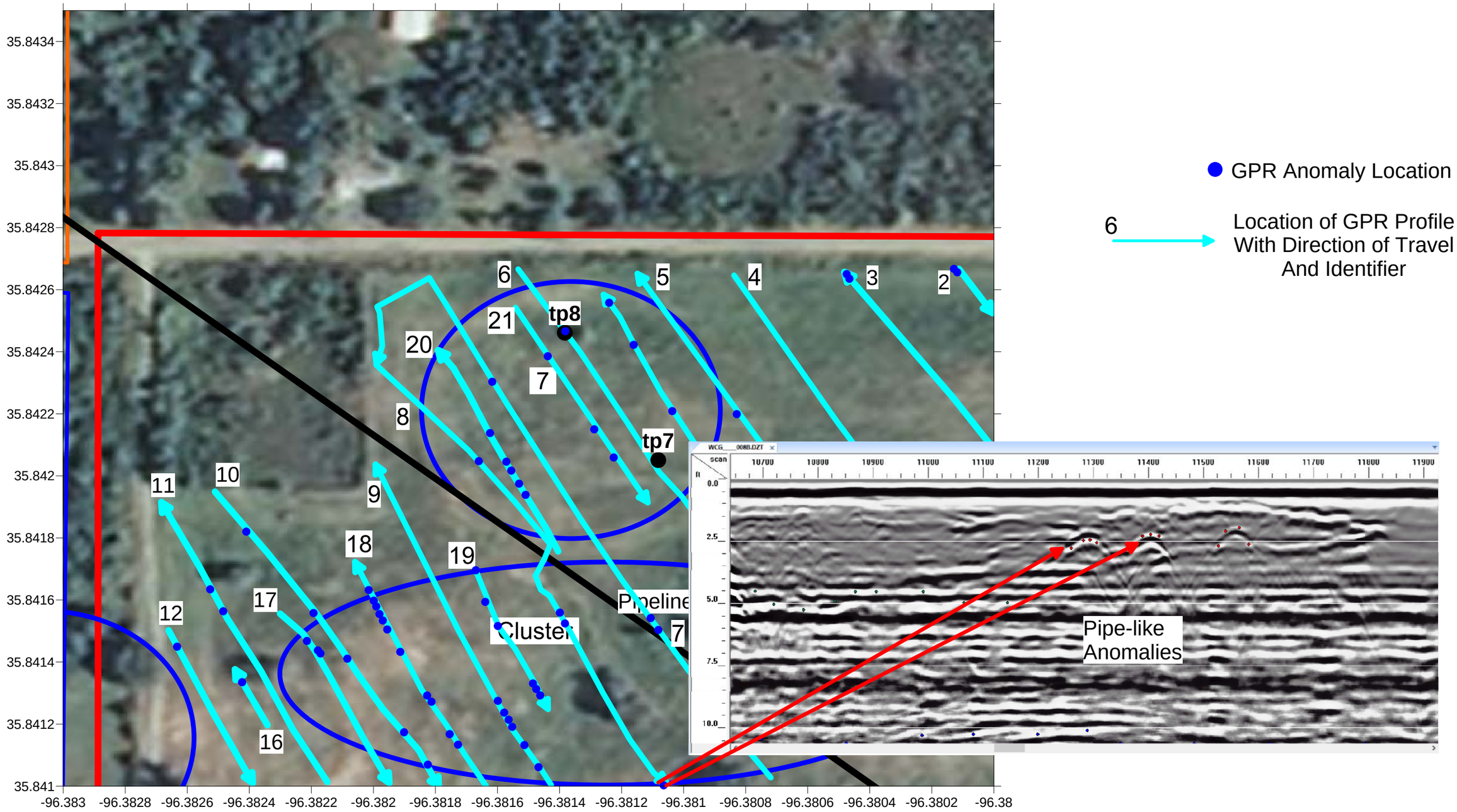
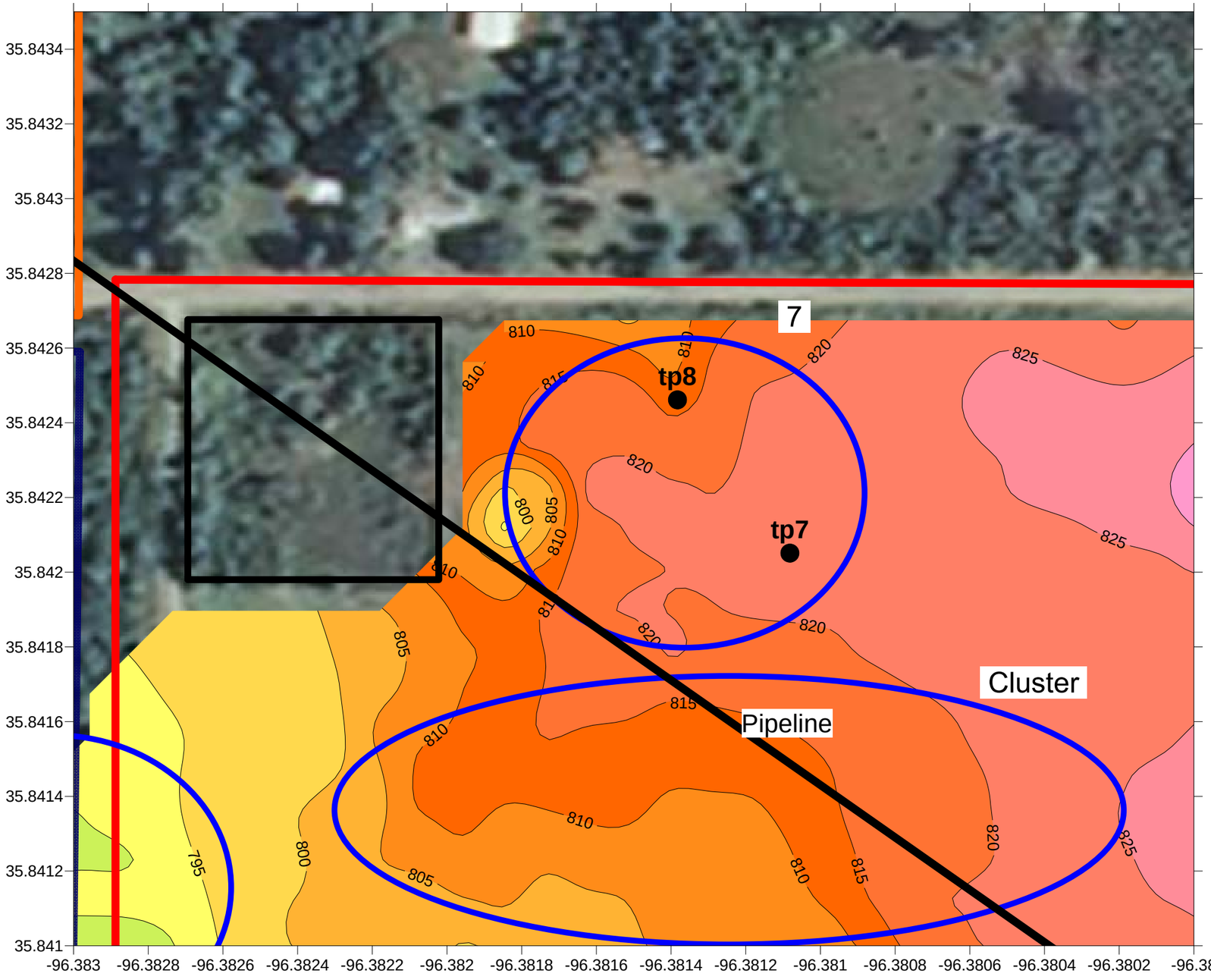


Figure 29
GPR Profiles
Tank Cluster and Investigation Area 7

Coordinates are presented in Latitude/Longitude



Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

● Test Pit Location with Identifier

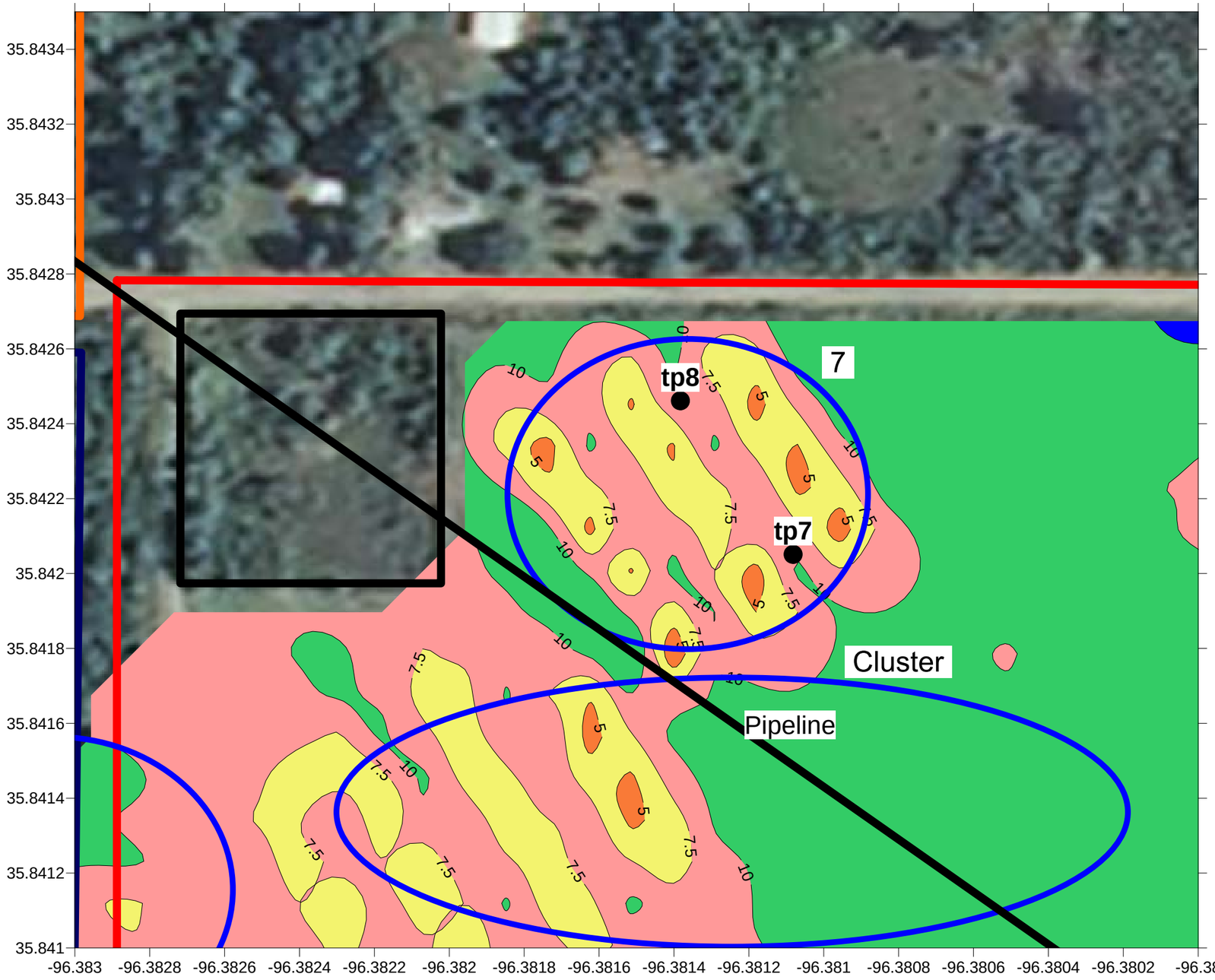
TP7
Bedrock depth greater than 5.5 feet

TP8
Bedrock depth greater than 7.4 feet

N
W E
S

Figure 30
Bedrock Elevation
Tank Cluster and Investigation Area 7

Coordinates are presented in Latitude/Longitude



Soil Thickness (Feet)

0 2.5 5 7.5 10 15 20

● Test Pit Location with Identifier

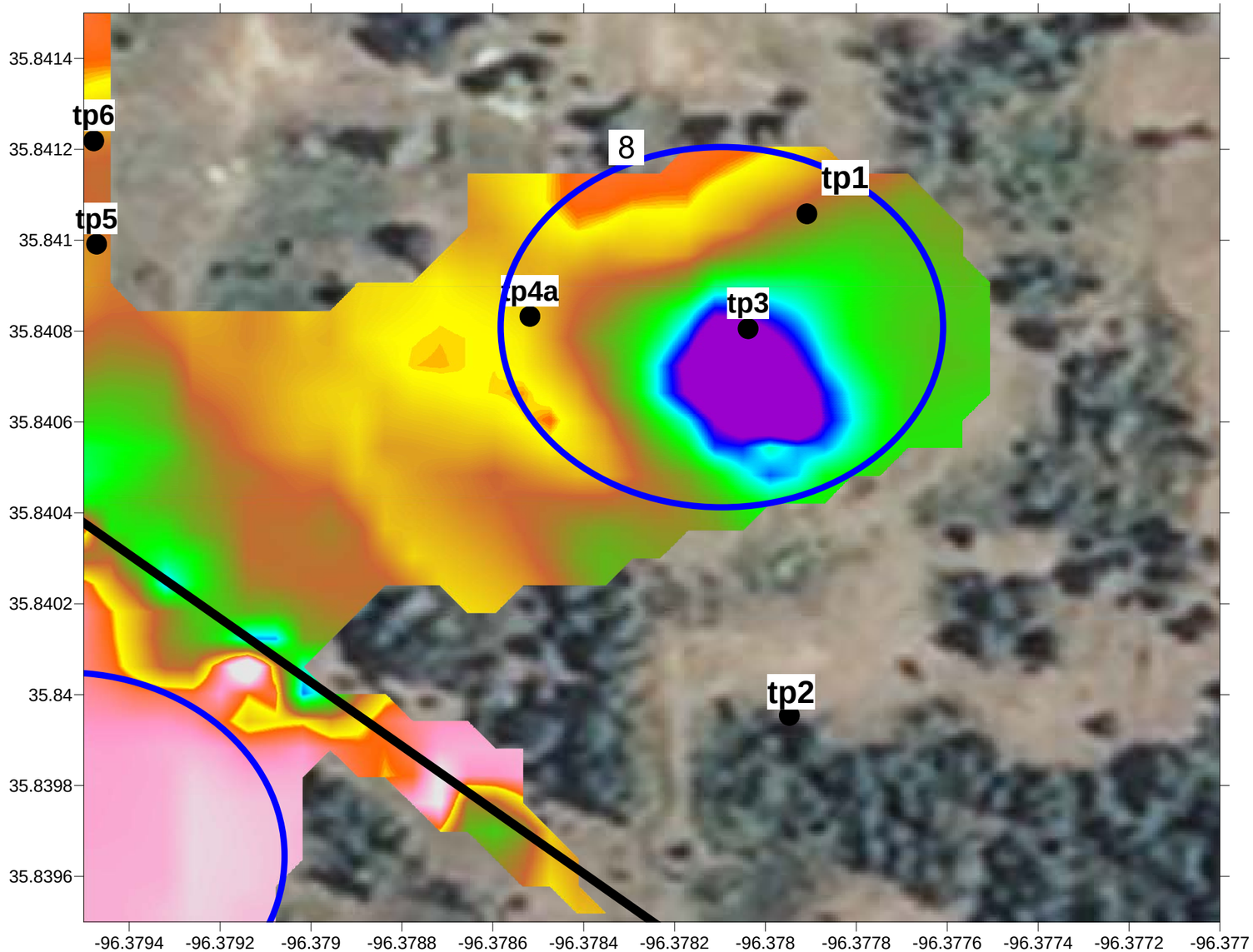
TP7
Bedrock depth greater than 5.5 feet

TP8
Bedrock depth greater than 7.4 feet

N
W E
S

Figure 31
Soil Thickness
Tank Cluster and Investigation Area 7

Coordinates are presented in Latitude/Longitude



Conductivity (mmhos/m)

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

● Test Pit Location with Identifier

TP1
Bedrock depth greater than 6.6 feet

TP2
Bedrock depth greater than 4.0 feet

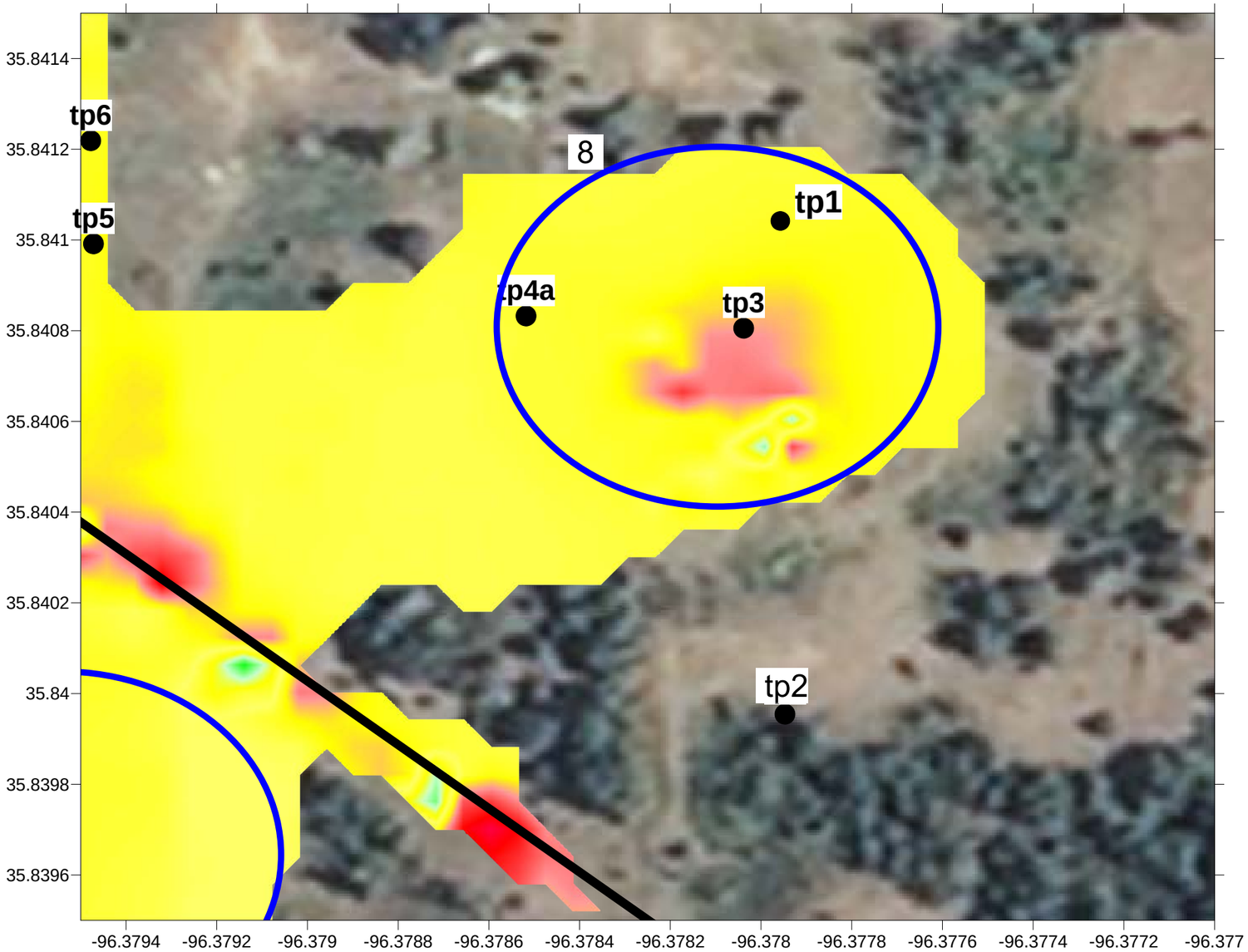
TP3
Bedrock depth greater than 2.3 feet
Dense grey clay at 2.3 feet

TP4a
Bedrock depth greater than 3.7 feet

N
W E
S

Figure 32
EM31 Conductivity Results
Investigation Area 8

Coordinates are presented in Latitude/Longitude



Inphase (ppt)

-20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20

● Test Pit Location with Identifier

TP1
Bedrock depth greater than 6.6 feet

TP2
Bedrock depth greater than 4.0 feet

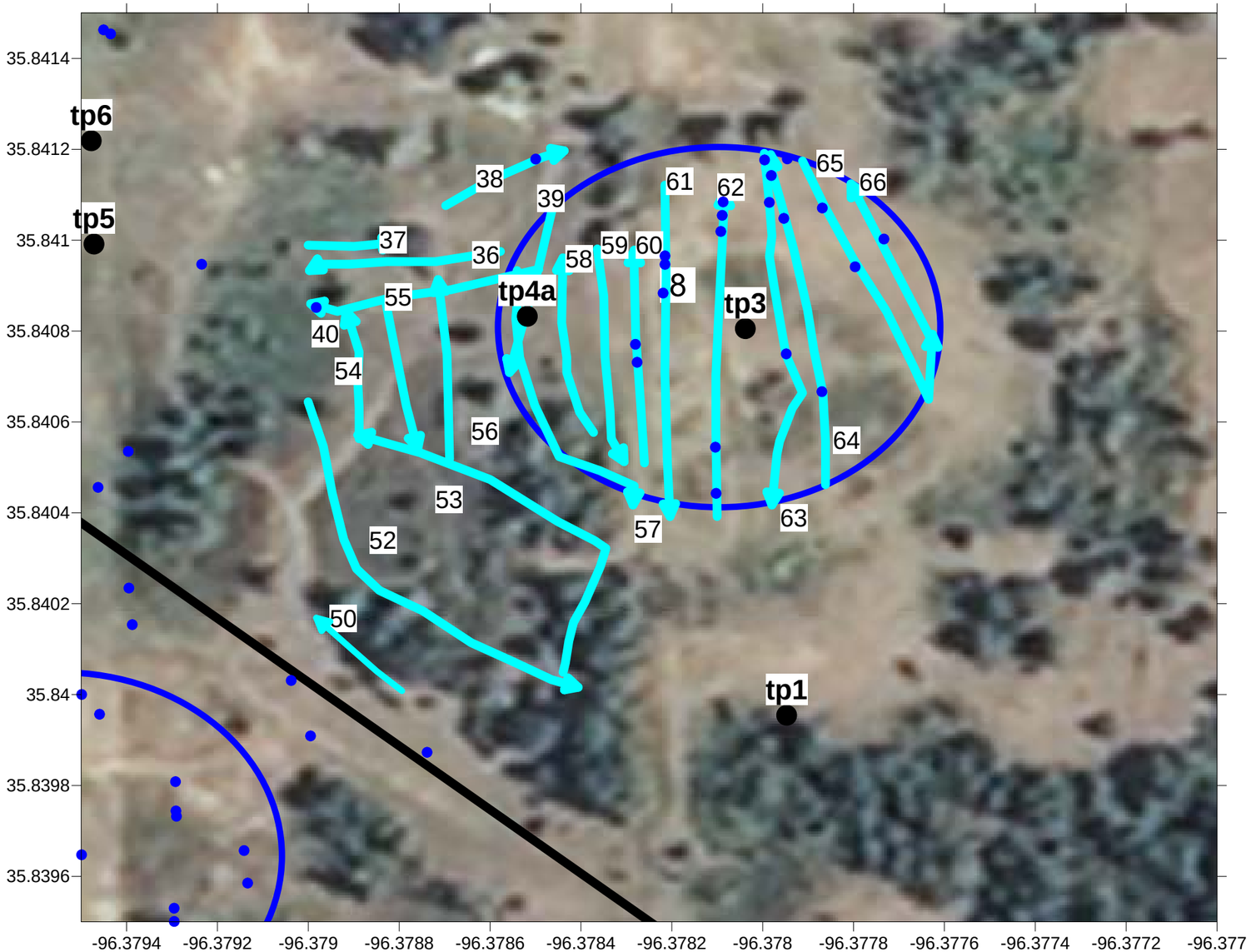
TP3
Bedrock depth greater than 2.3 feet
Dense grey clay at 2.3 feet

TP4a
Bedrock depth greater than 3.7 feet

N
W E
S

Figure 33
EM31 Inphase Results
Investigation Area 8

Coordinates are presented in Latitude/Longitude



GPR Anomaly Location

66 → Location of GPR Profile With Direction of Travel And Identifier

● Test Pit Location with Identifier

TP1
Bedrock depth greater than 6.6 feet

TP2
Bedrock depth greater than 4.0 feet

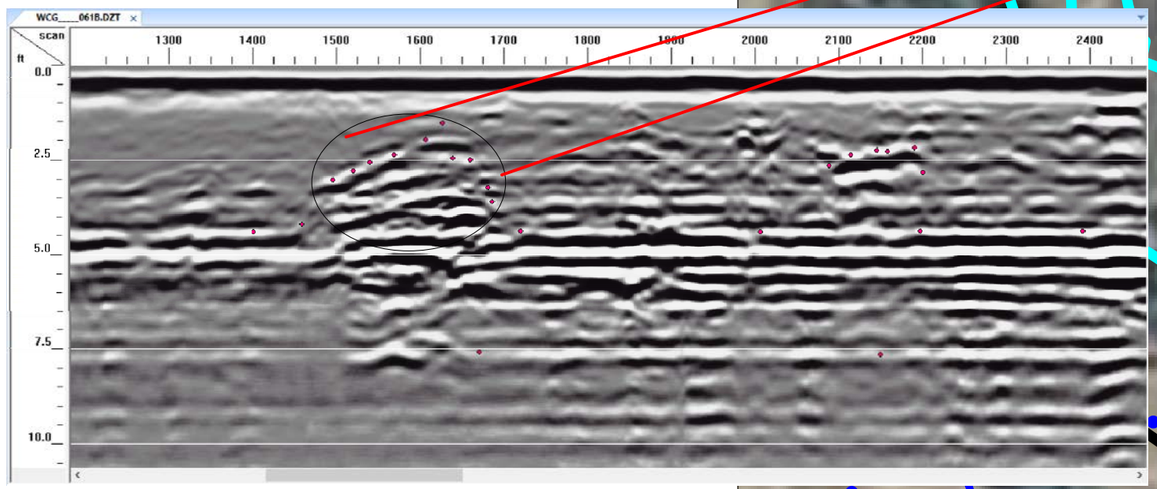
TP3
Bedrock depth greater than 2.3 feet
Dense grey clay at 2.3 feet

TP4a
Bedrock depth greater than 3.7 feet

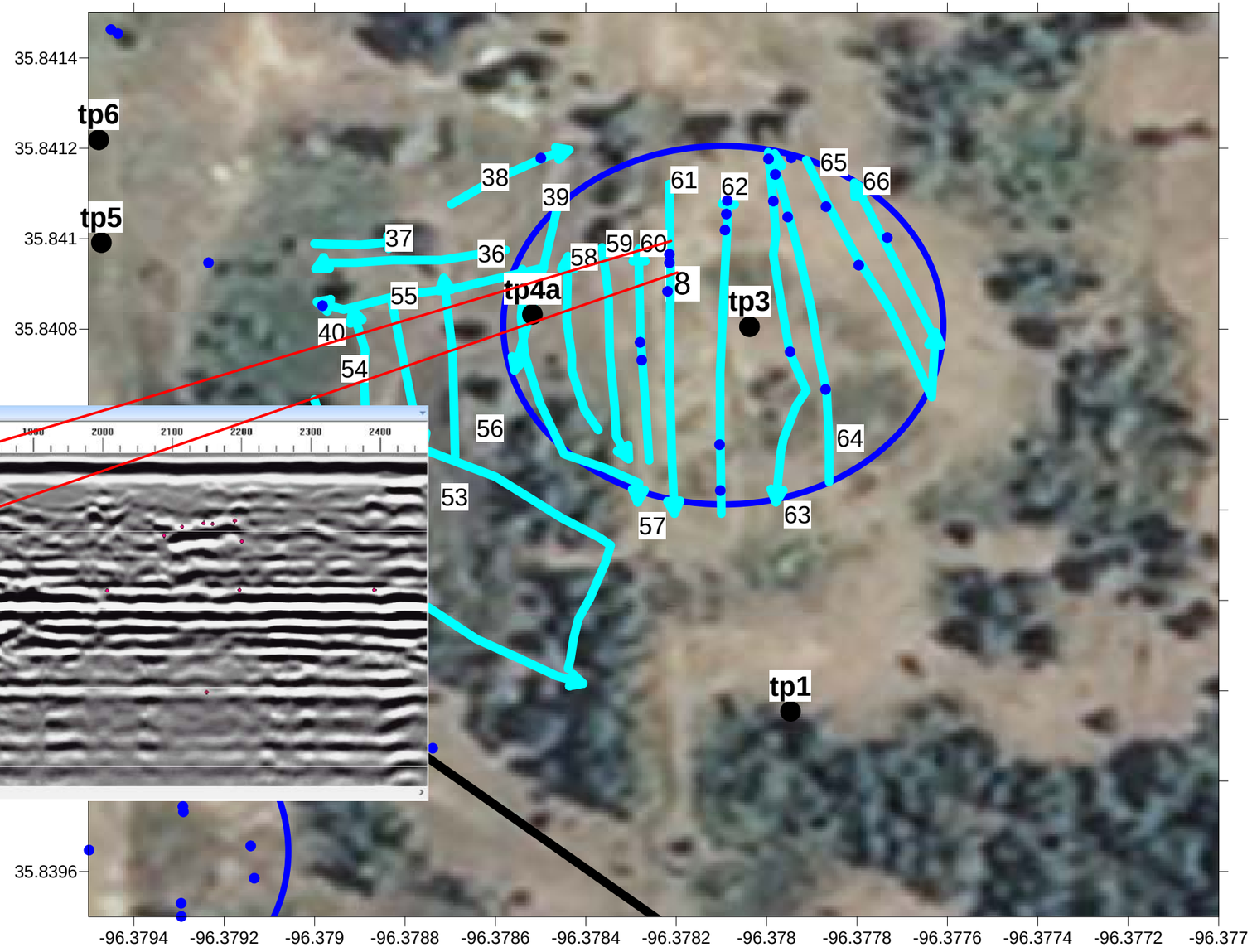
N
W E
S

Figure 34
Location of GPR Traverses and Anomalies
Investigation Area 8

Coordinates are presented in Latitude/Longitude



Unknown Anomaly



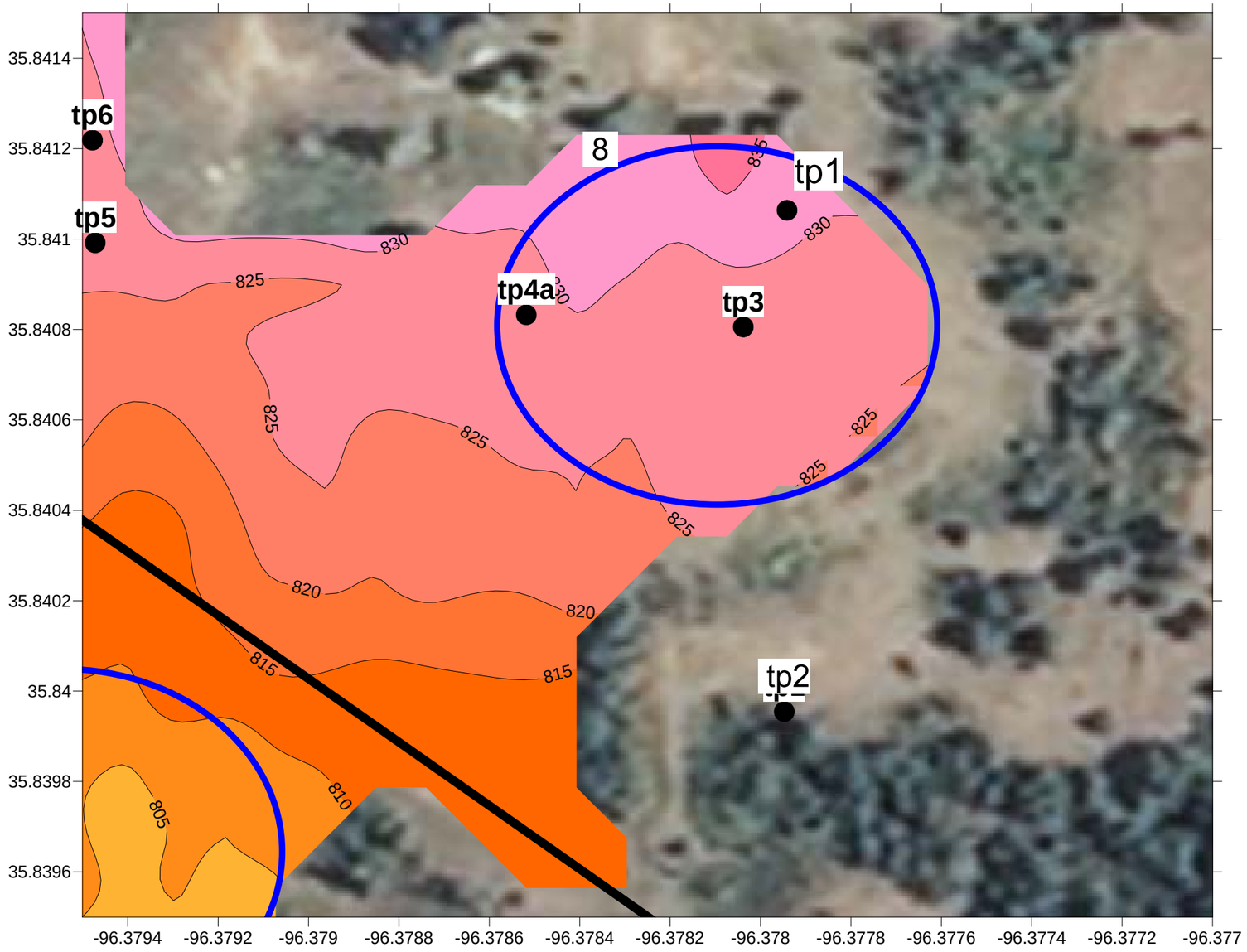
● GPR Anomaly Location

66 → Location of GPR Profile With Direction of Travel And Identifier

N
W
E
S

Figure 35
GPR Profiles
Investigation Area 8

Coordinates are presented in Latitude/Longitude



Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

● Test Pit Location with Identifier

TP1
Bedrock depth greater than 6.6 feet

TP2
Bedrock depth greater than 4.0 feet

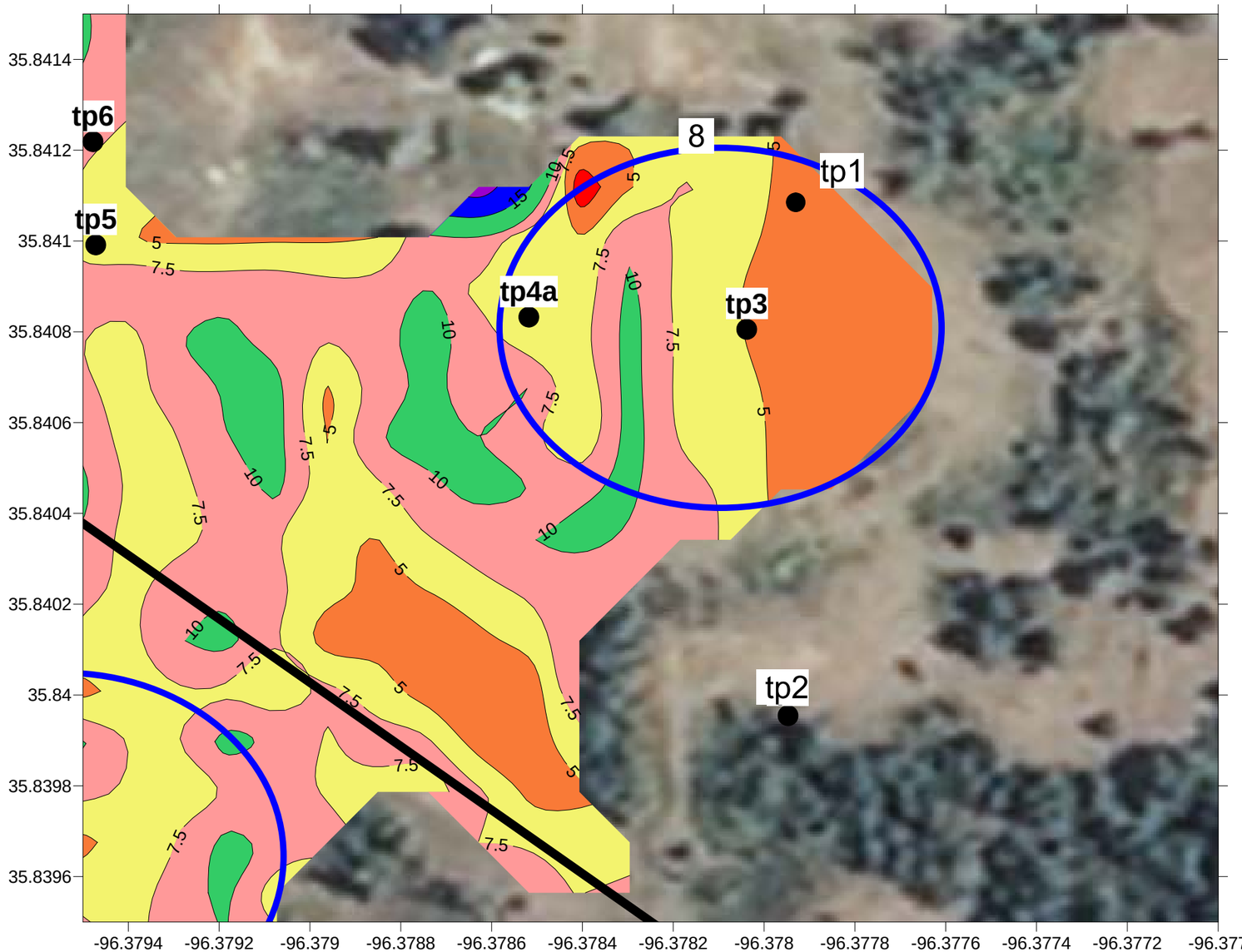
TP3
Bedrock depth greater than 2.3 feet
Dense grey clay at 2.3 feet

TP4a
Bedrock depth greater than 3.7 feet

N
W E
S

Figure 36
Bedrock Elevation
Investigation Area 8

Coordinates are presented in Latitude/Longitude



Soil Thickness (Feet)

0 2.5 5 7.5 10 15 20

● Test Pit Location with Identifier

TP1
Bedrock depth greater than 6.6 feet

TP2
Bedrock depth greater than 4.0 feet

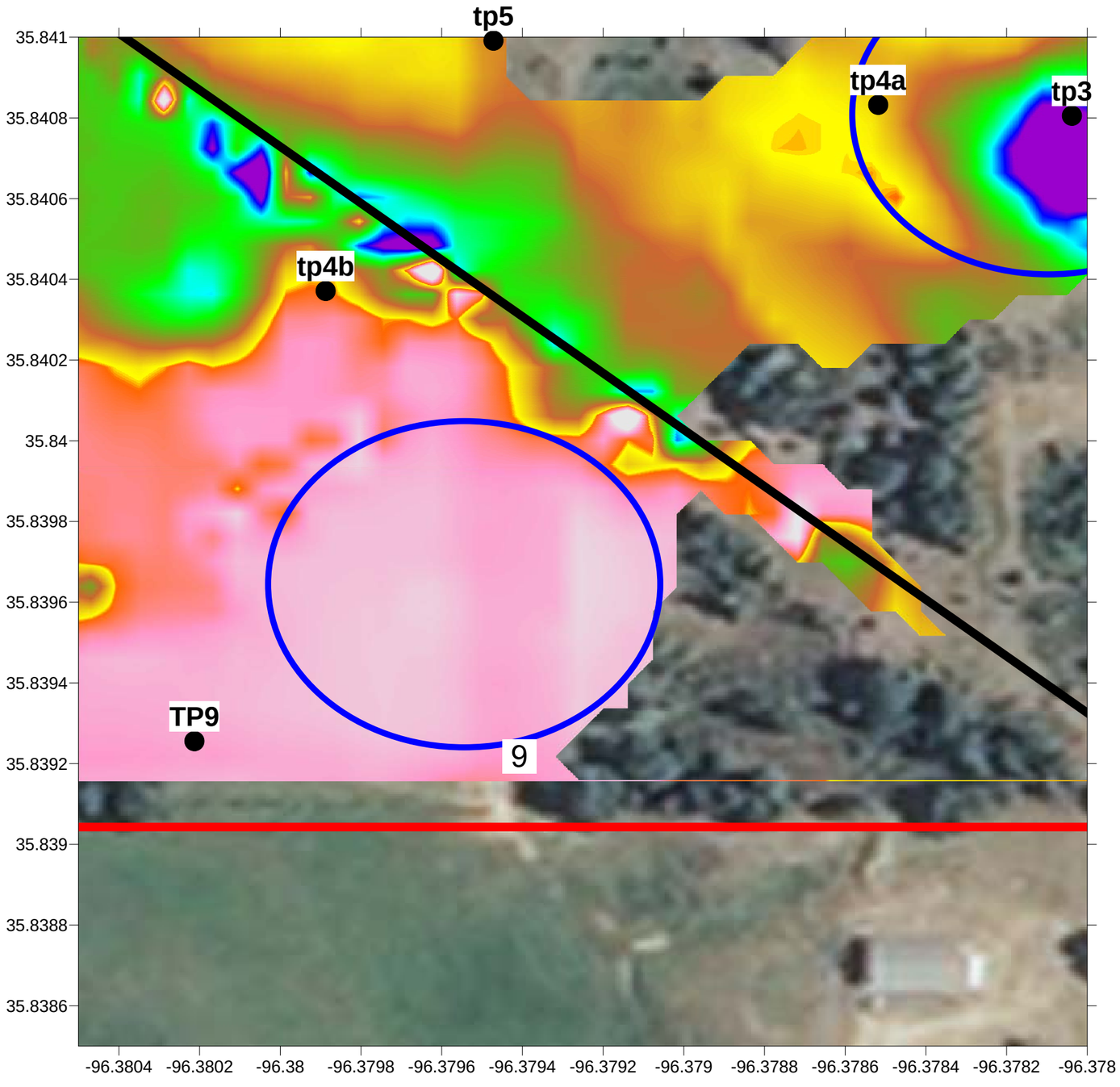
TP3
Bedrock depth greater than 2.3 feet
Dense grey clay at 2.3 feet

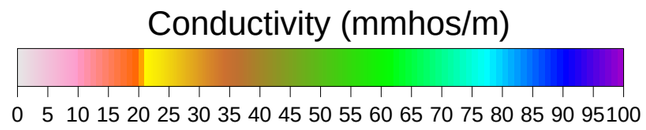
TP4a
Bedrock depth greater than 3.7 feet

N
W E
S

Figure 37
Soil Thickness
Investigation Area 8

Coordinates are presented in Latitude/Longitude





● Test Pit Location with Identifier

TP4b
Bedrock depth greater than 6.1 feet

TP5
Bedrock depth greater than 5.5 feet

TP9
Bedrock depth greater than 7.5

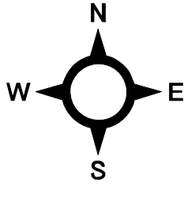
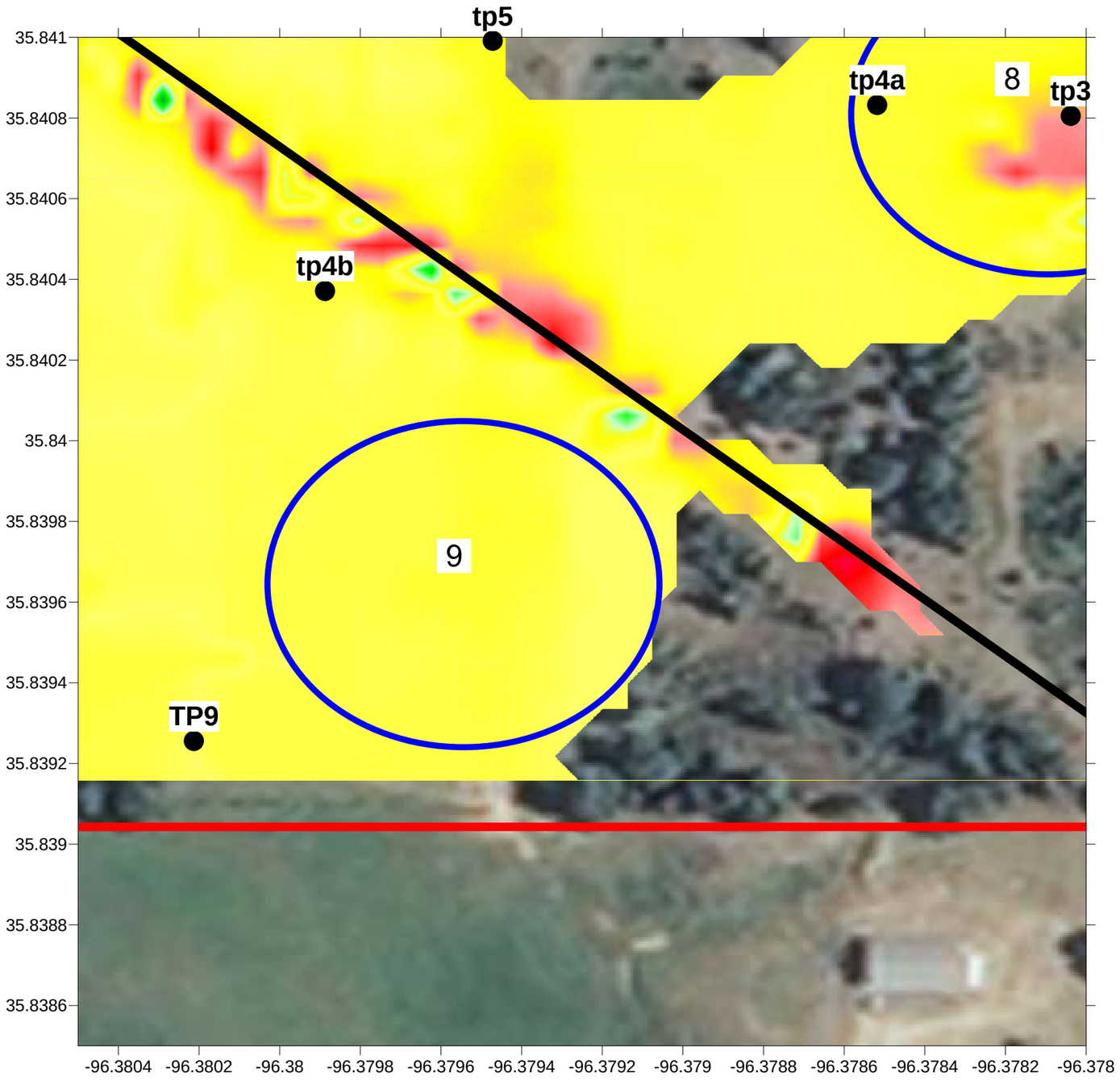


Figure 38
EM31 Conductivity Results
Investigation Area 9

Coordinates are presented in Latitude/Longitude



Inphase (ppt)

-20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20

TP4b
Bedrock depth greater than 6.1 feet

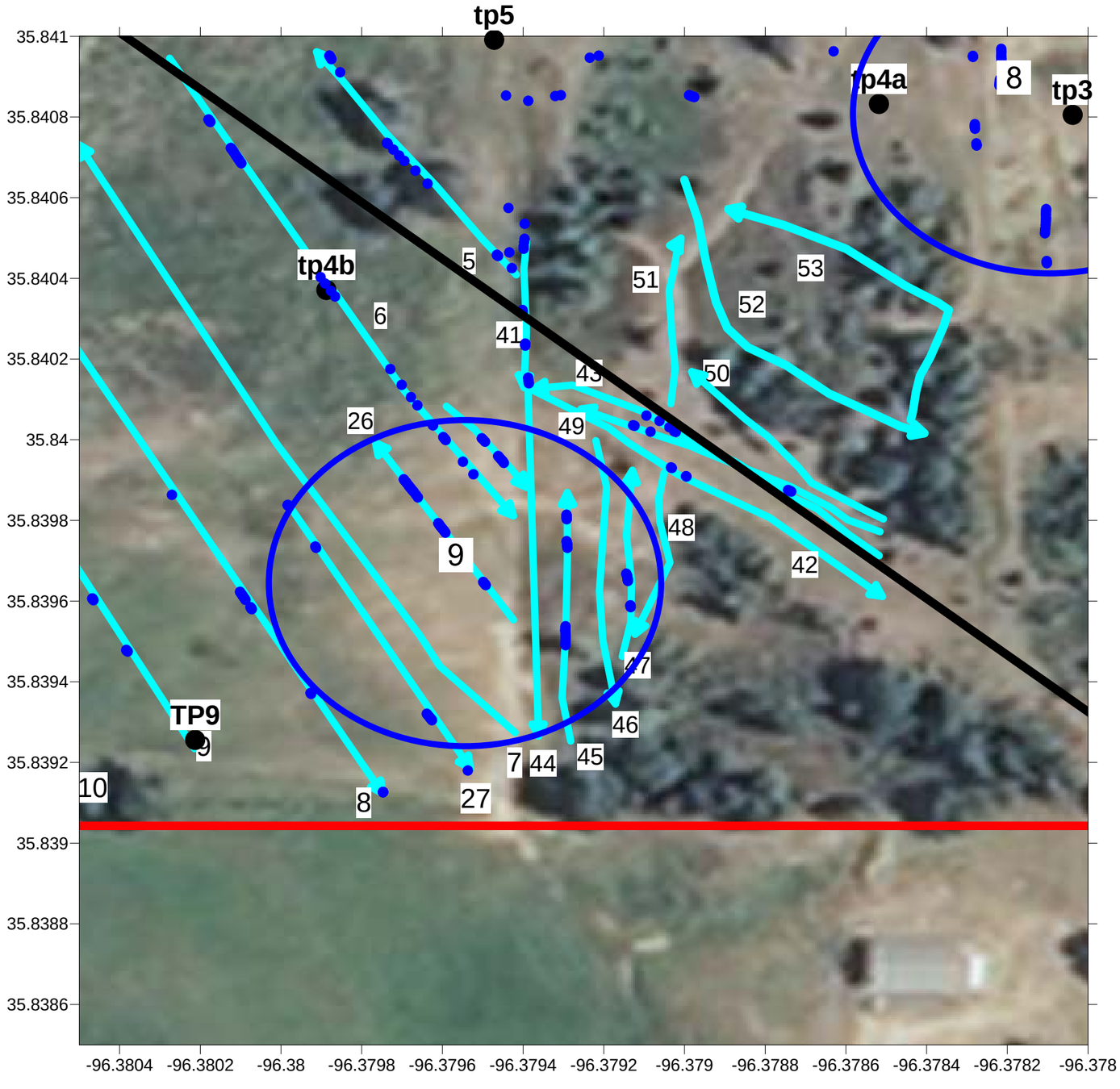
TP5
Bedrock depth greater than 5.5 feet

TP9
Bedrock depth greater than 7.5

N
W E
S

Figure 39
EM31 Inphase Results
Investigation Area 9

Coordinates are presented in Latitude/Longitude



GPR Anomaly Location

66 → Location of GPR Profile With Direction of Travel And Identifier

TP4b
Bedrock depth greater than 6.1 feet

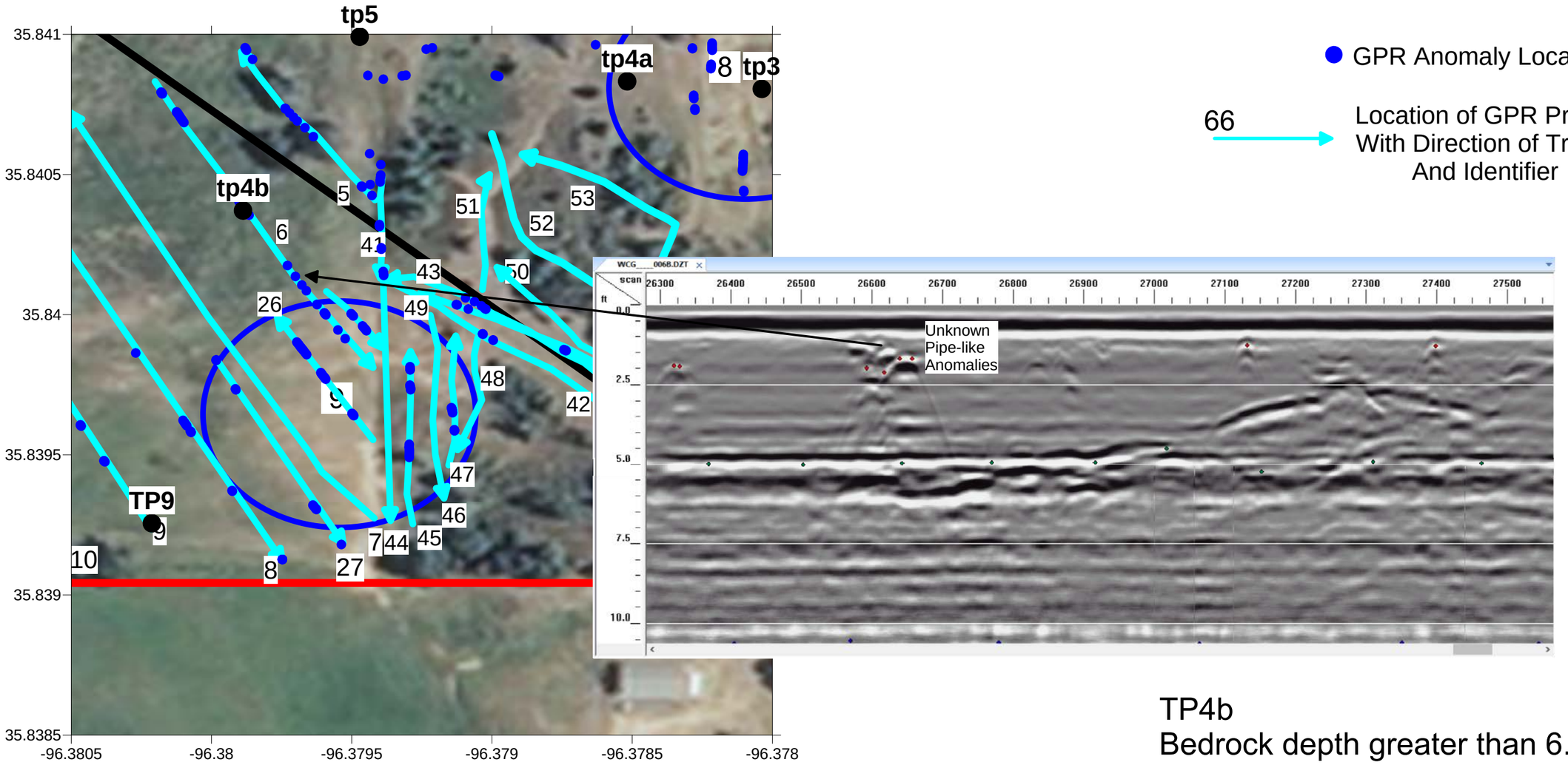
TP5
Bedrock depth greater than 5.5 feet

TP9
Bedrock depth greater than 7.5

N W E S

Figure 40
Location of GPR Traverses and Anomalies
Investigation Area 9

Coordinates are presented in Latitude/Longitude



GPR Anomaly Location

66 → Location of GPR Profile With Direction of Travel And Identifier

TP4b
Bedrock depth greater than 6.1 feet

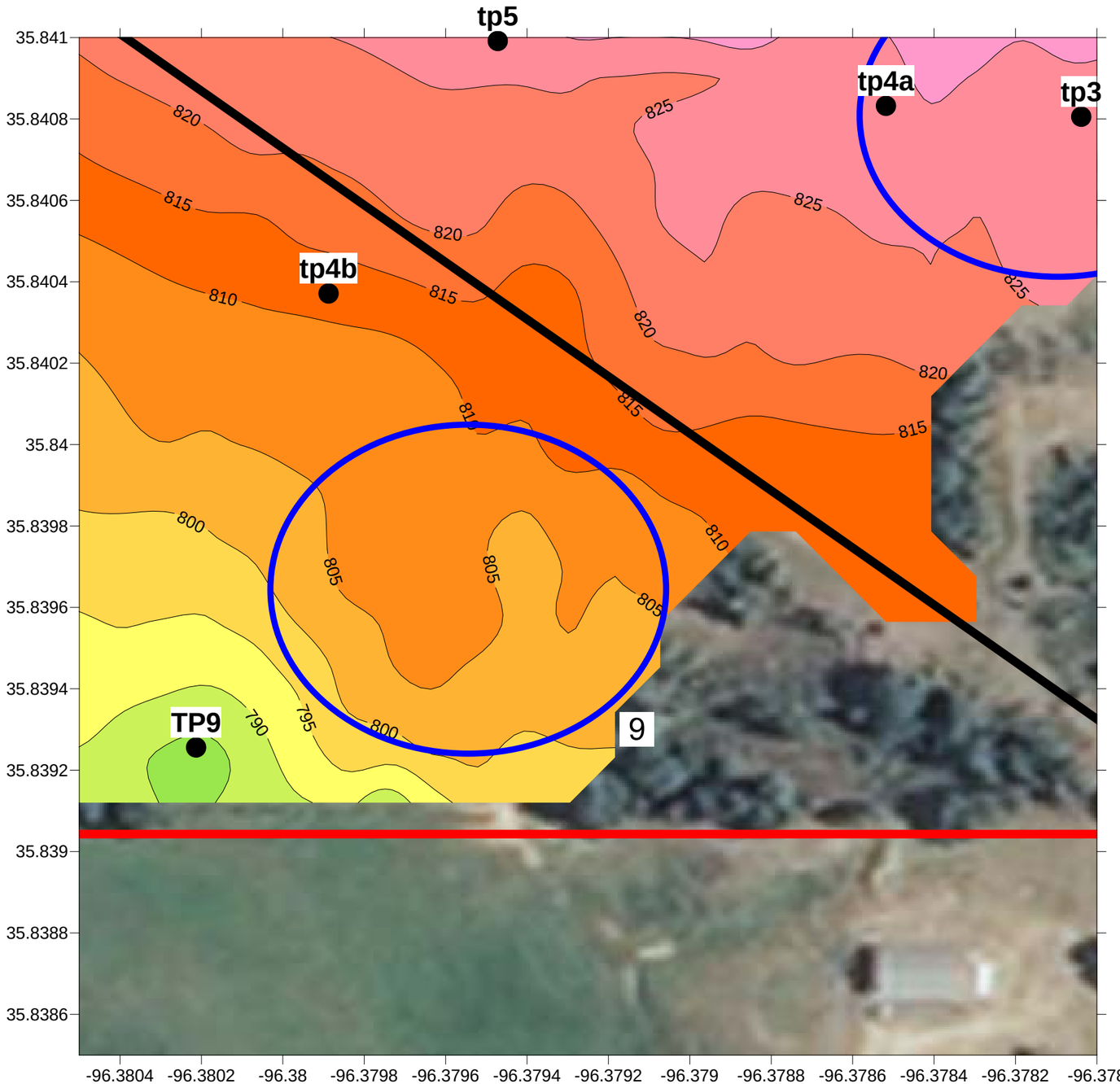
TP5
Bedrock depth greater than 5.5 feet

TP9
Bedrock depth greater than 7.5

Figure 41
GPR Profiles
Investigation Area 9

N
W
E
S

Coordinates are presented in Latitude/Longitude



Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

TP4b
Bedrock depth greater than 6.1 feet

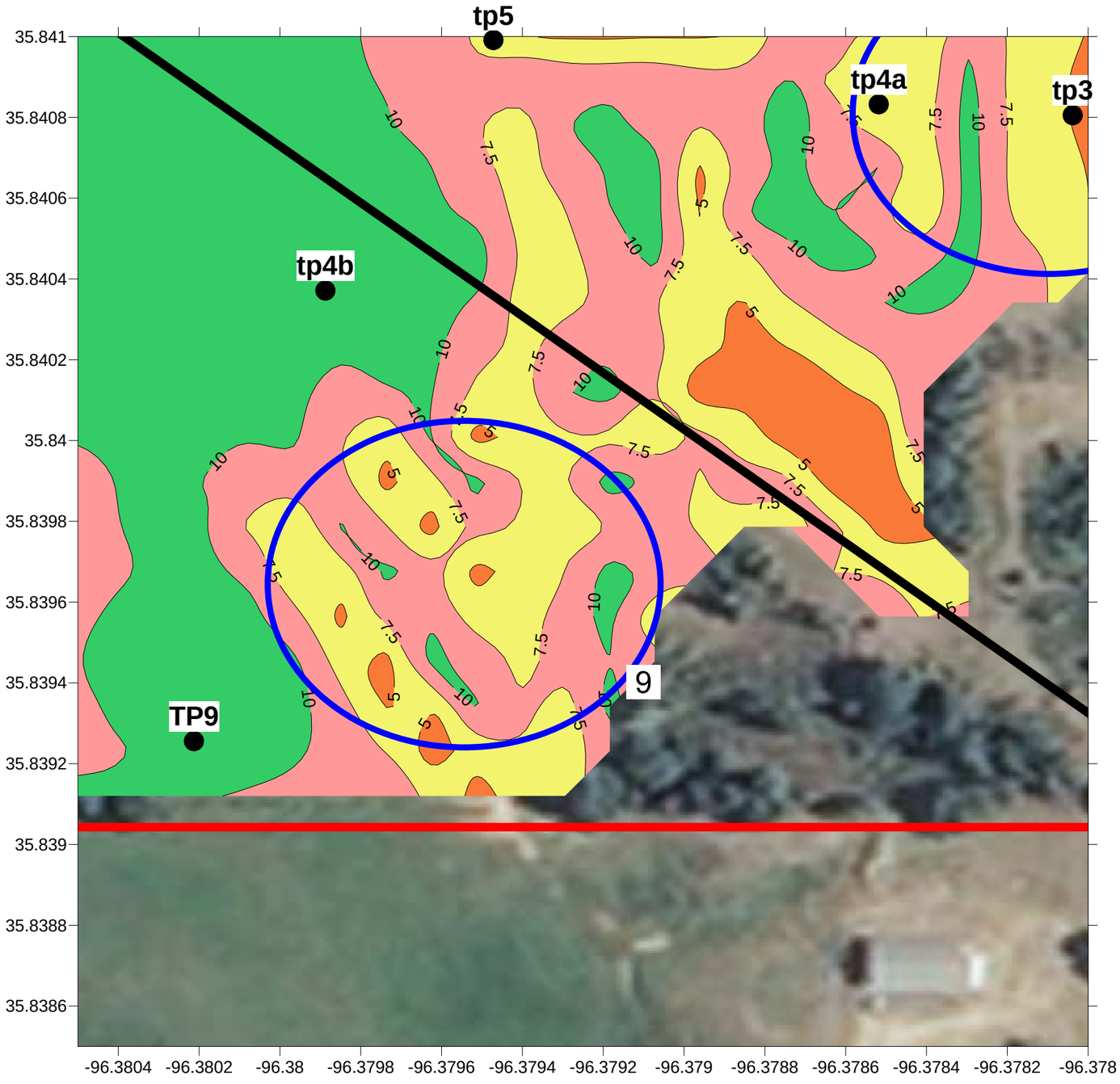
TP5
Bedrock depth greater than 5.5 feet

TP9
Bedrock depth greater than 7.5

N
W E
S

Figure 42
Bedrock Elevation
Investigation Area 9

Coordinates are presented in Latitude/Longitude



Soil Thickness (Feet)

0 2.5 5 7.5 10 15 20

TP4b
Bedrock depth greater than 6.1 feet

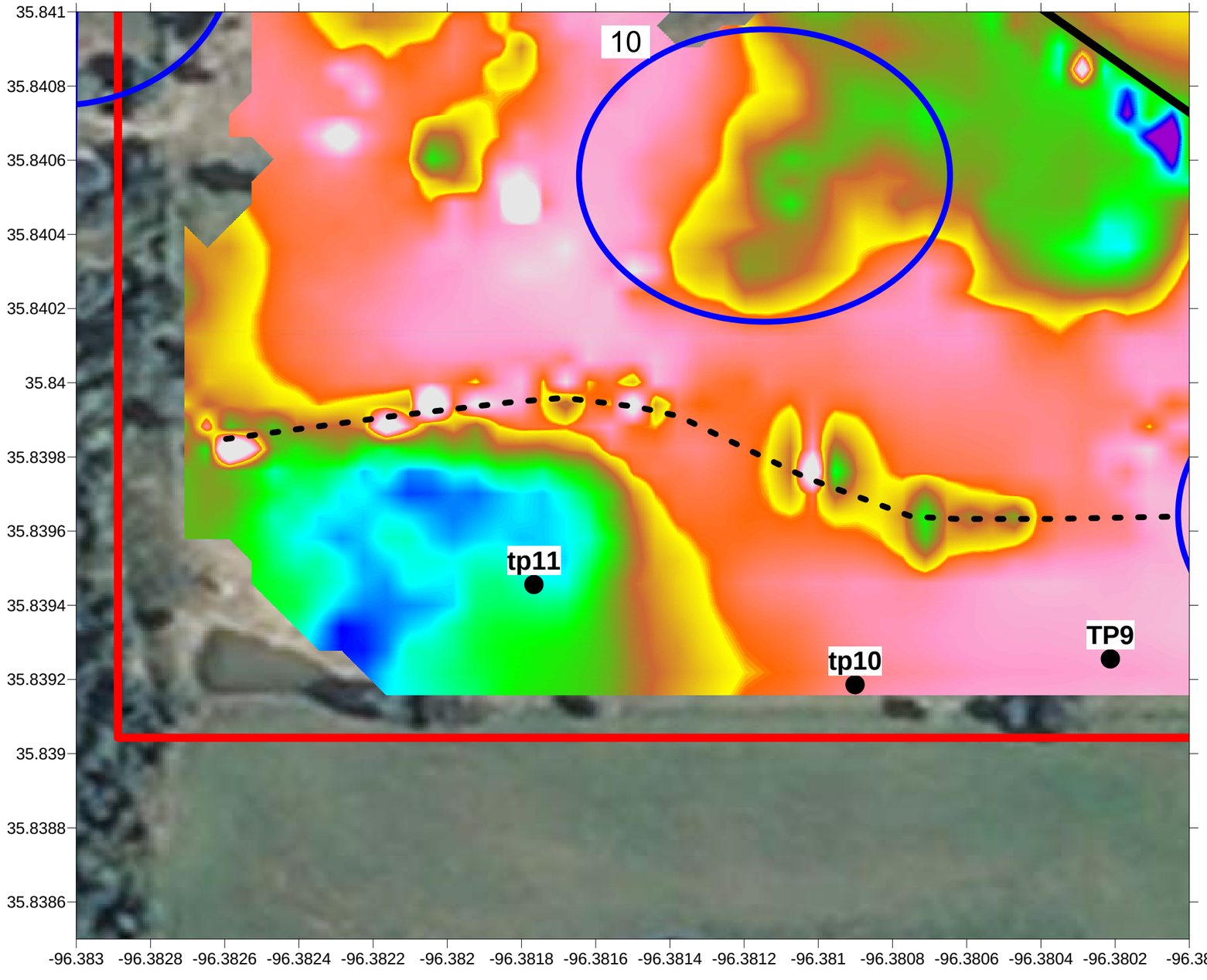
TP5
Bedrock depth greater than 5.5 feet

TP9
Bedrock depth greater than 7.5

N
W E
S

Figure 43
Soil Thickness
Investigation Area 9

Coordinates are presented in Latitude/Longitude



Conductivity (mmhos/m)

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

● Test Pit Location with Identifier

TP9
Bedrock depth greater than 7.5

TP10
Bedrock depth greater than 9.5 feet

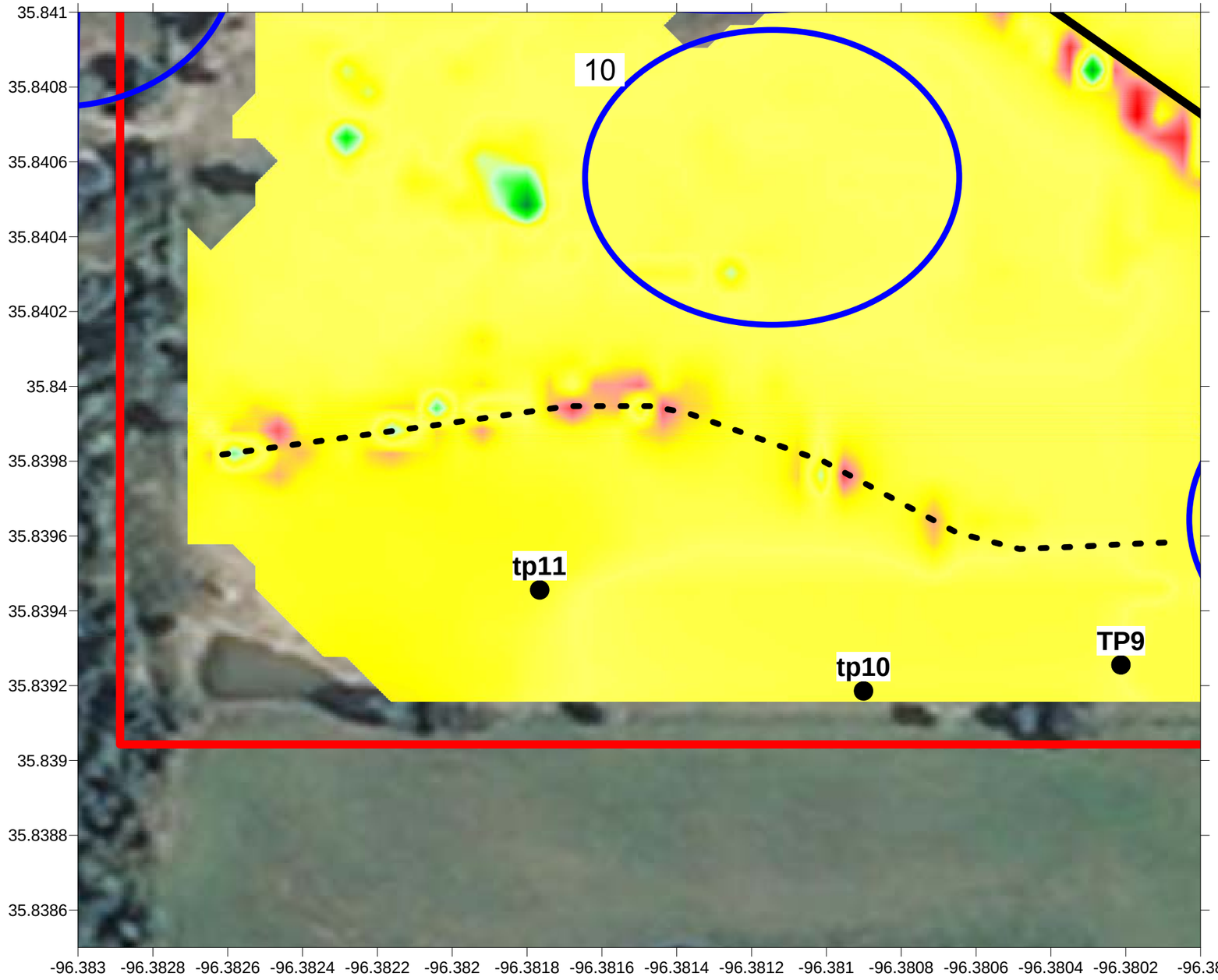
TP11
Bedrock depth greater than 9.5 feet

- - - - Unknown Pipelike Anomaly

N
W E
S

Figure 44
EM31 Conductivity Results
Investigation Area 10

Coordinates are presented in Latitude/Longitude



Inphase (ppt)

-20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12 14 16 18 20

● Test Pit Location with Identifier

TP9
Bedrock depth greater than 7.5

TP10
Bedrock depth greater than 9.5 feet

TP11
Bedrock depth greater than 9.5 feet

- - - - Unknown Pipelike Anomaly

N
W E
S

Figure 45
EM31 Inphase Results
Investigation Area 10

Coordinates are presented in Latitude/Longitude

GPR Anomaly Location

66 → Location of GPR Profile With Direction of Travel And Identifier

Test Pit Location with Identifier

TP9
Bedrock depth greater than 7.5

TP10
Bedrock depth greater than 9.5 feet

TP11
Bedrock depth greater than 9.5 feet

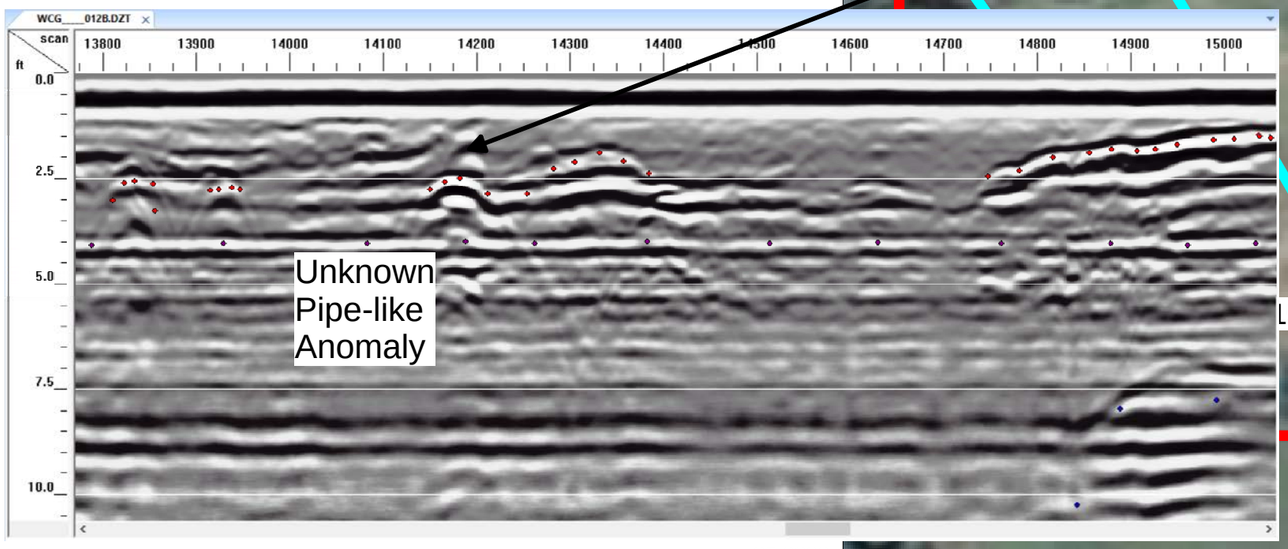
N W E S

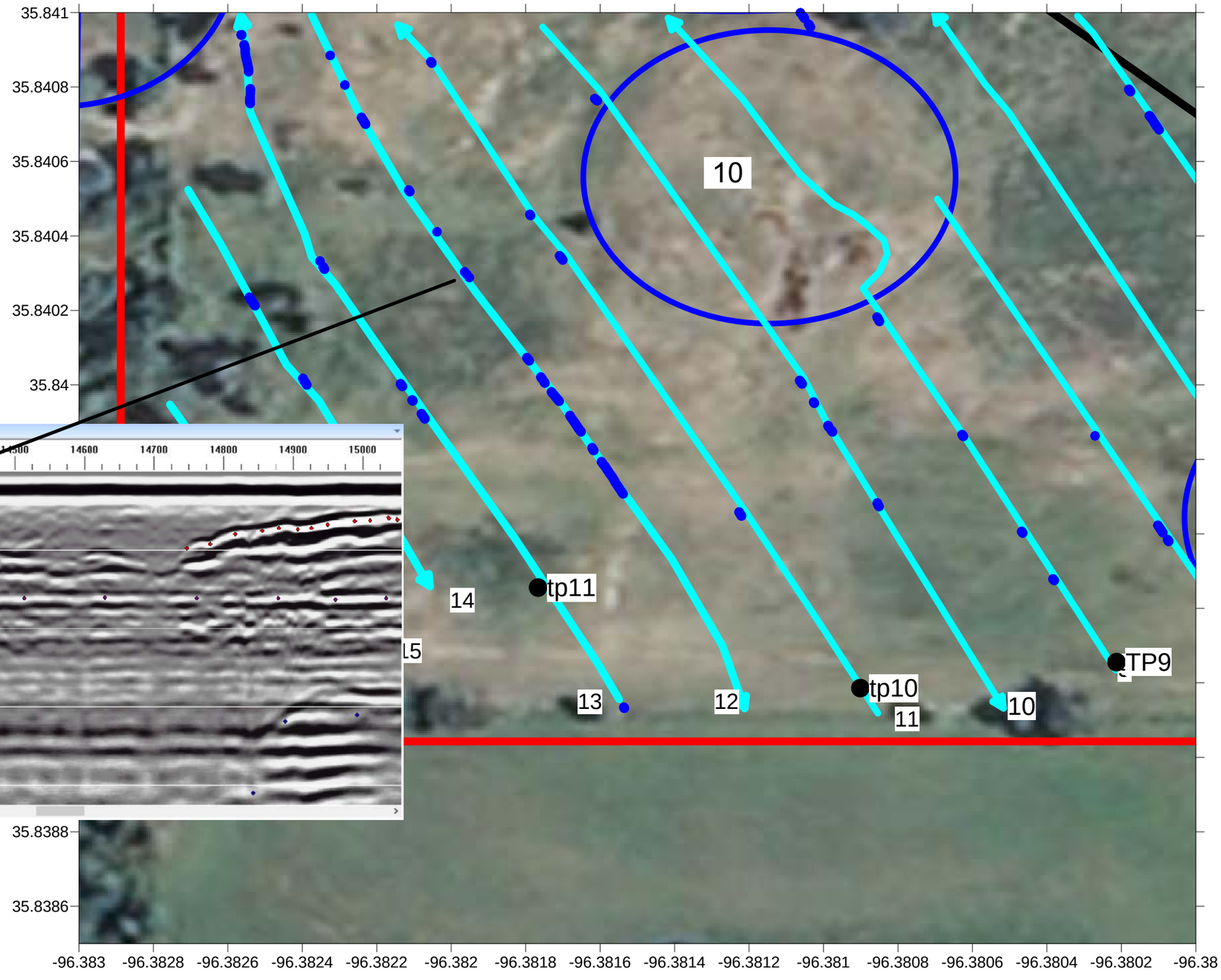
Figure 46
Location of GPR Traverses and Anomalies
Investigation Area 10

Coordinates are presented in Latitude/Longitude

GPR Anomaly Location

66 → Location of GPR Profile With Direction of Travel And Identifier

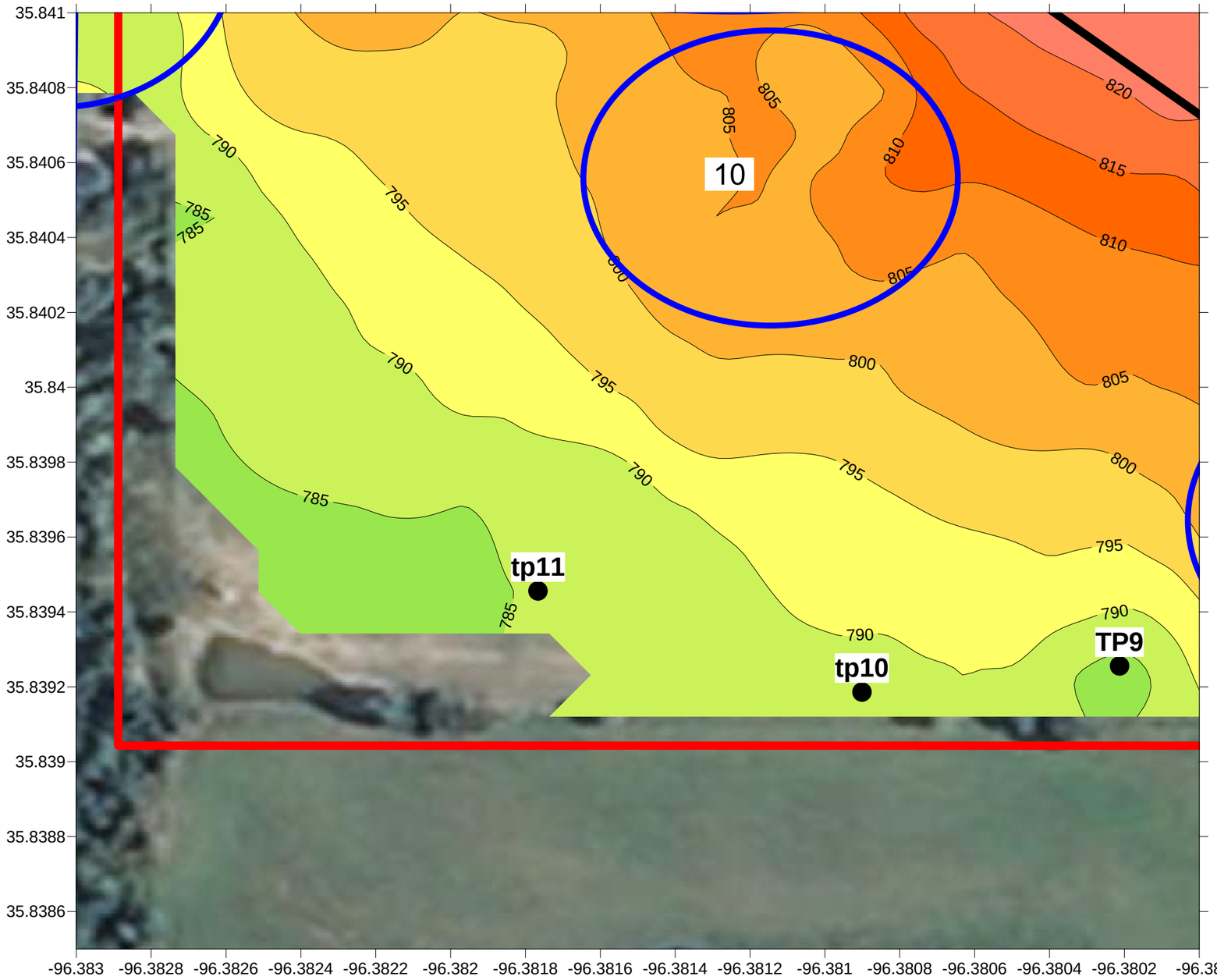




N
W E
S

Figure 47
GPR Profiles
Investigation Area 10

Coordinates are presented in Latitude/Longitude



Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

● Test Pit Location with Identifier

TP9
Bedrock depth greater than 7.5

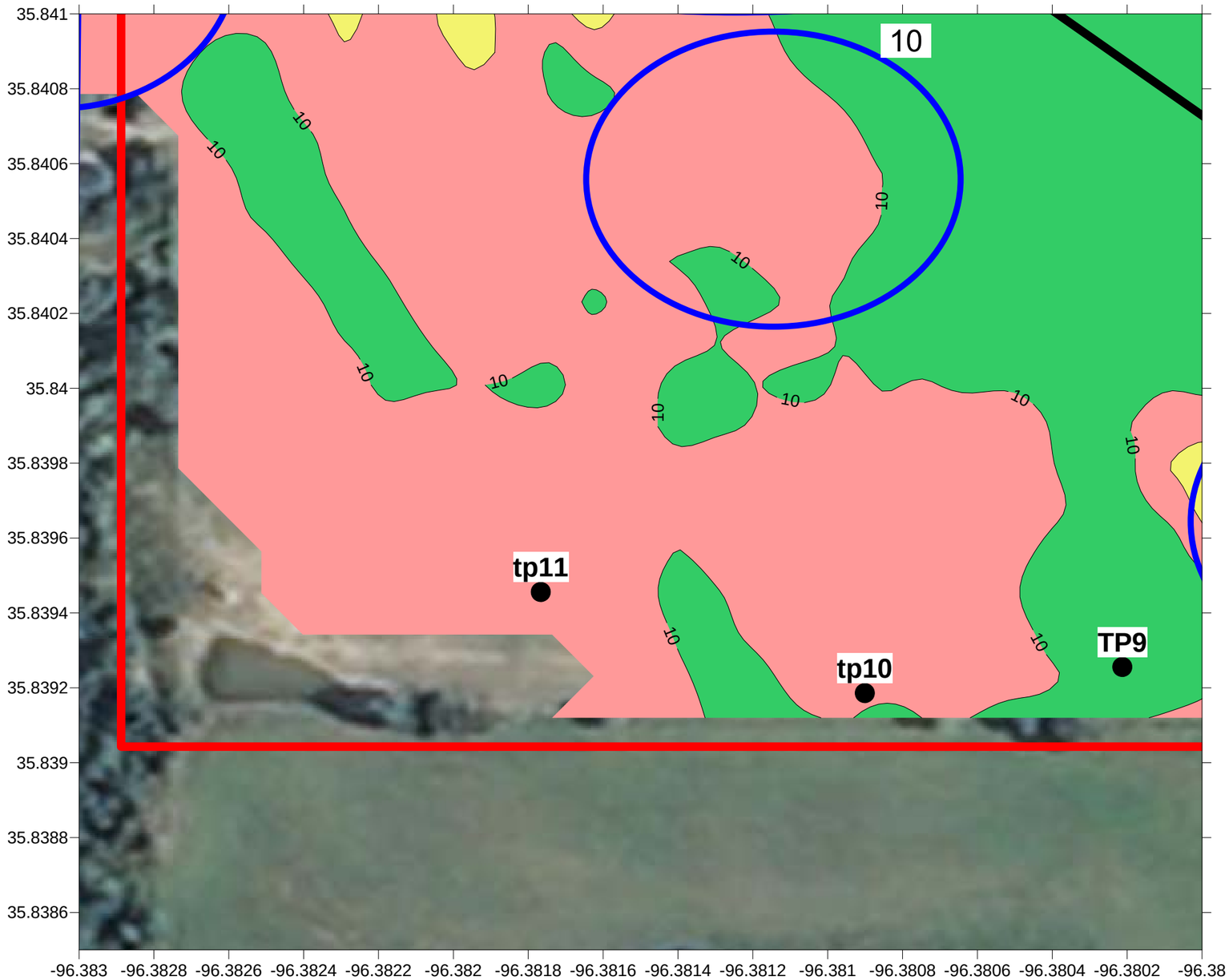
TP10
Bedrock depth greater than 9.5 feet

TP11
Bedrock depth greater than 9.5 feet

N
W E
S

Figure 48
Bedrock Elevation
Investigation Area 10

Coordinates are presented in Latitude/Longitude



Soil Thickness (Feet)

0 2.5 5 7.5 10 15 20

● Test Pit Location with Identifier

TP9
Bedrock depth greater than 7.5

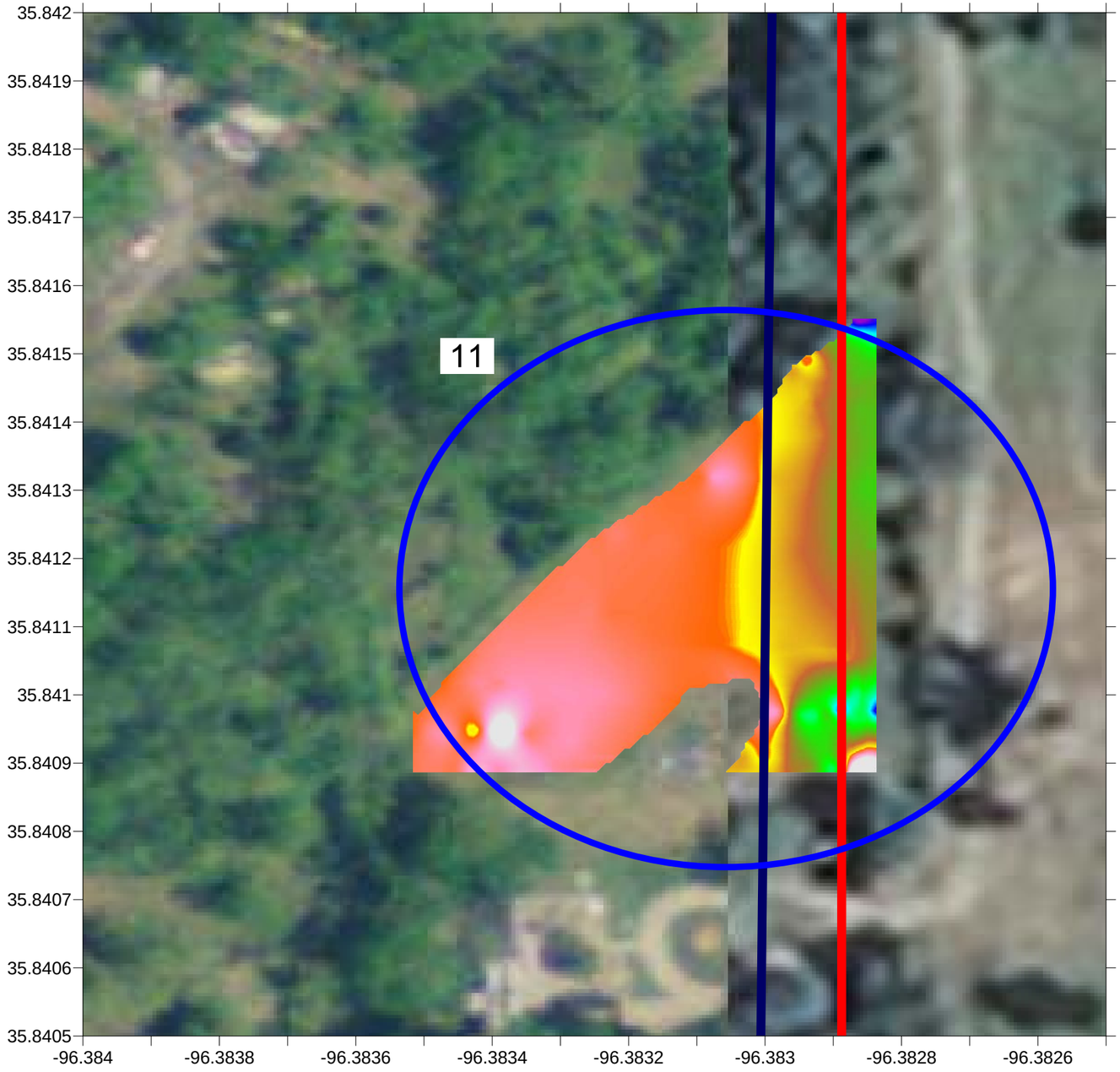
TP10
Bedrock depth greater than 9.5 feet

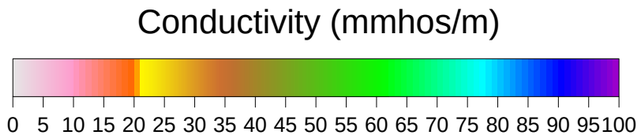
TP11
Bedrock depth greater than 9.5 feet

N
W E
S

Figure 49
Soil Thickness
Investigation Area 10

Coordinates are presented in Latitude/Longitude





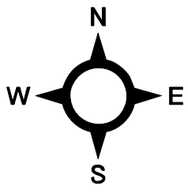


Figure 50
EM31 Conductivity Results
Investigation Area 11

Coordinates are presented in Latitude/Longitude

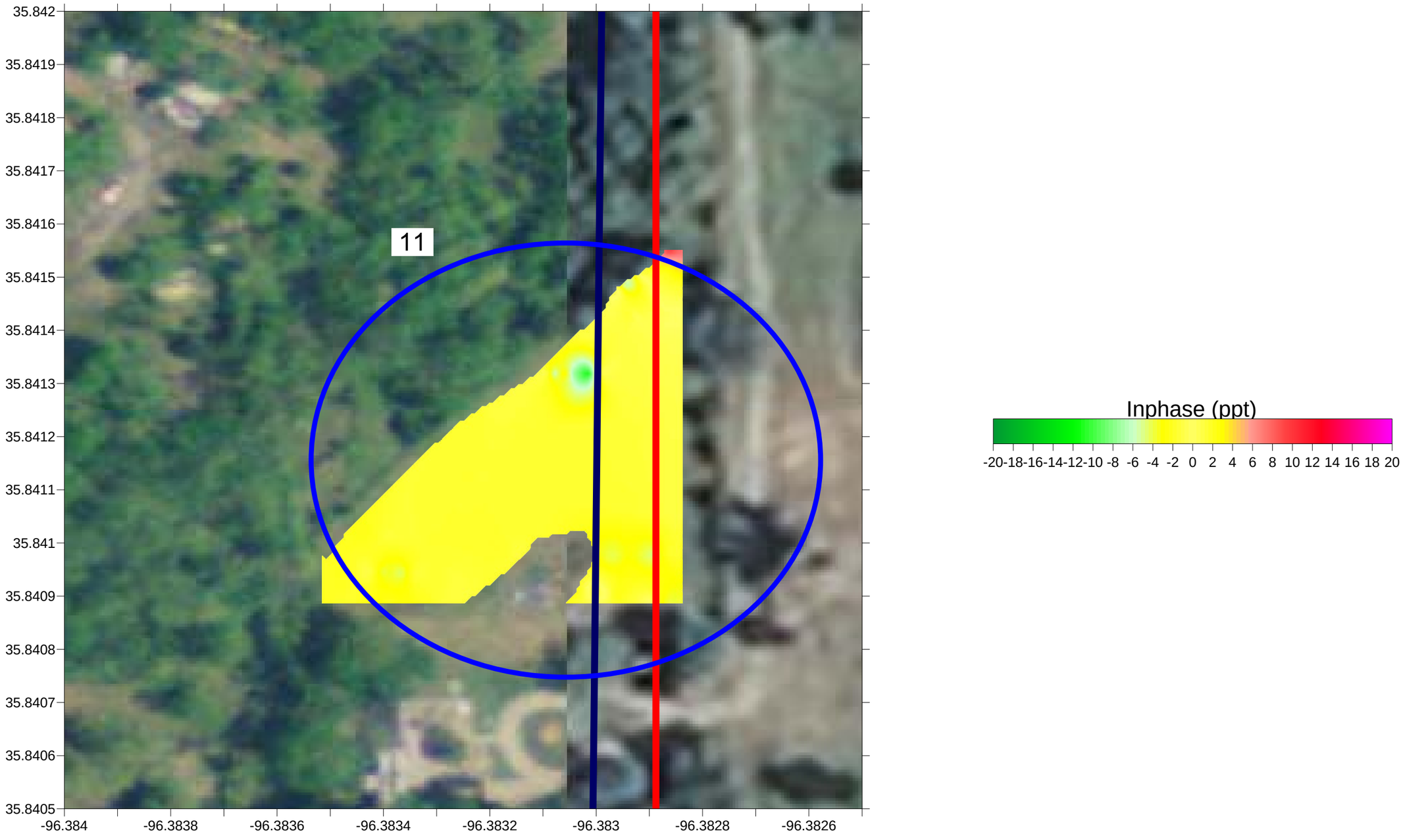
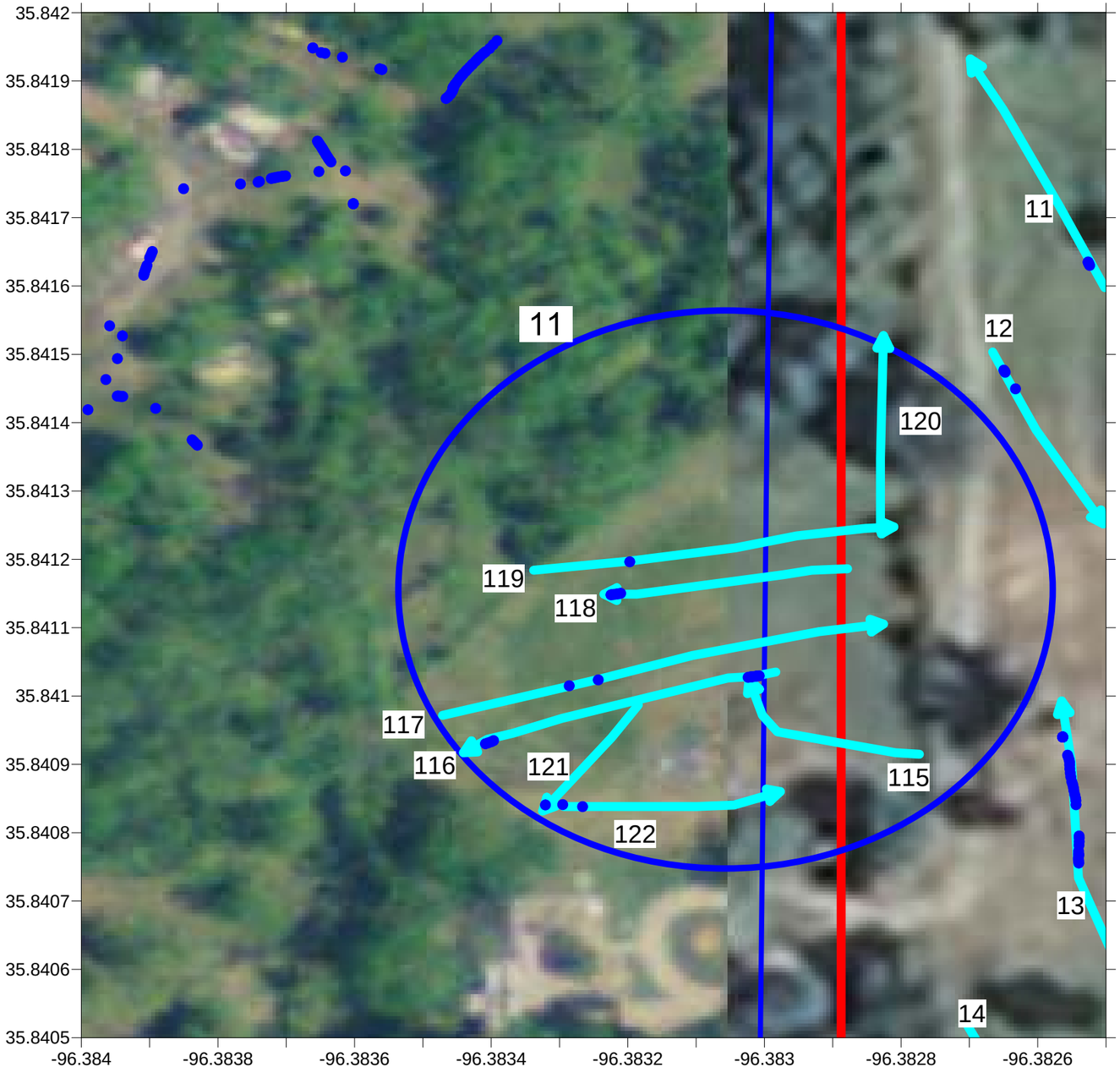


Figure 51
EM31 Inphase Results
Investigation Area 11

Coordinates are presented in Latitude/Longitude



GPR Anomaly Location

66 → Location of GPR Profile With Direction of Travel And Identifier

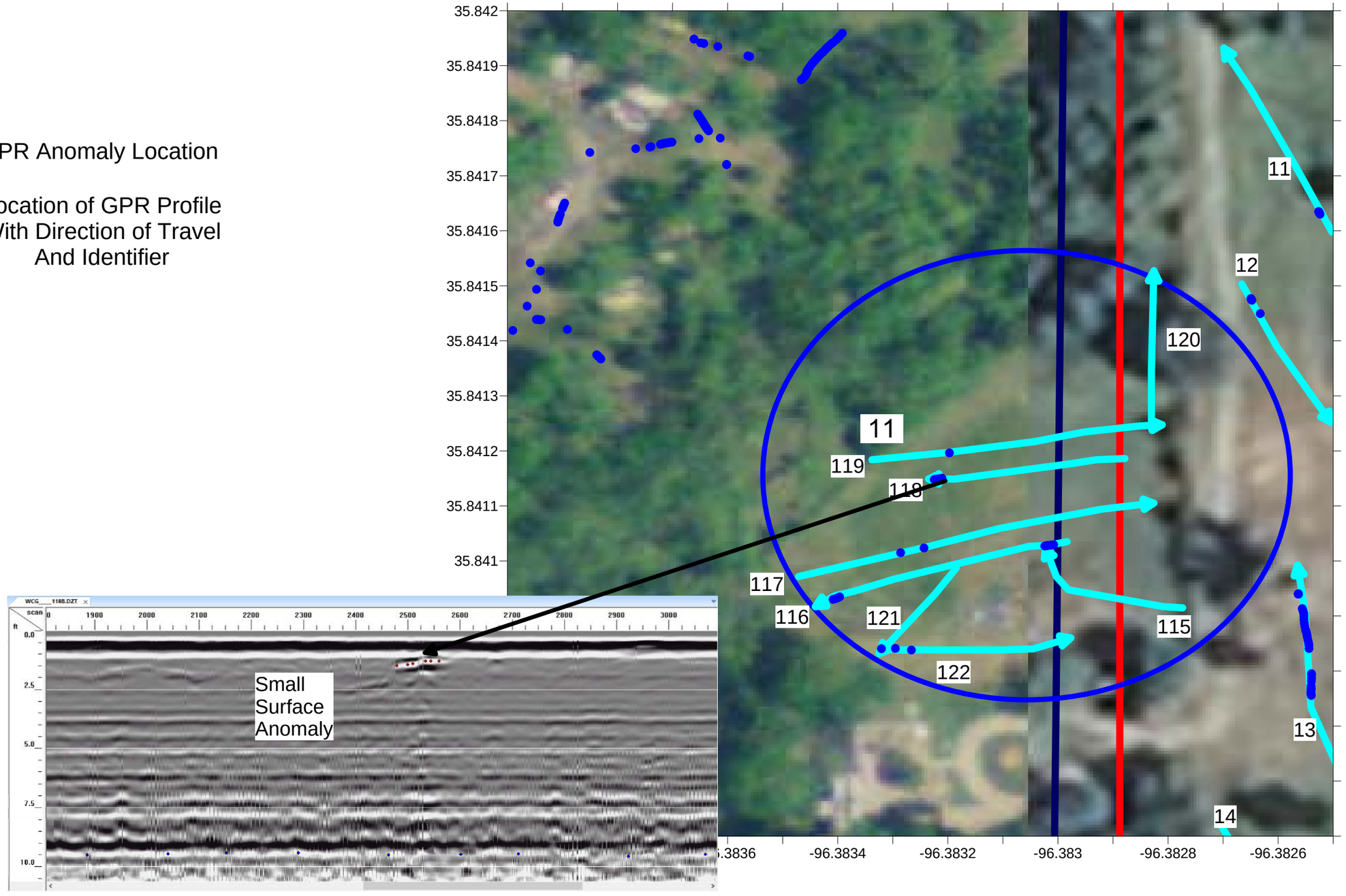
N
W E
S

Figure 52
Locations of GPR Traverses and Anomalies
Investigation Area 11

Coordinates are presented in Latitude/Longitude

GPR Anomaly Location

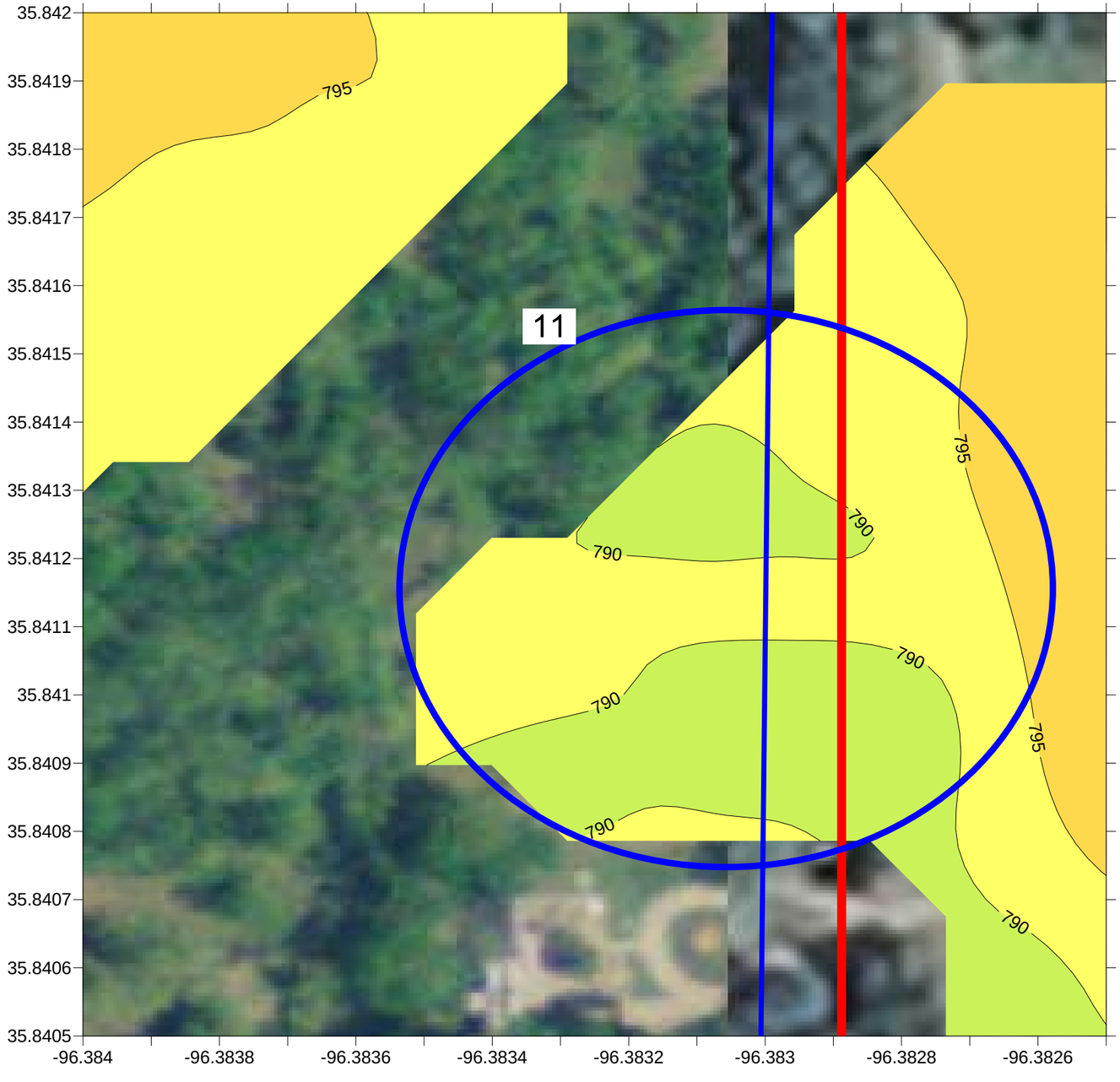
66 → Location of GPR Profile With Direction of Travel And Identifier



N
W E
S

Figure 53
GPR Profiles
Investigation Area 11

Coordinates are presented in Latitude/Longitude



Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

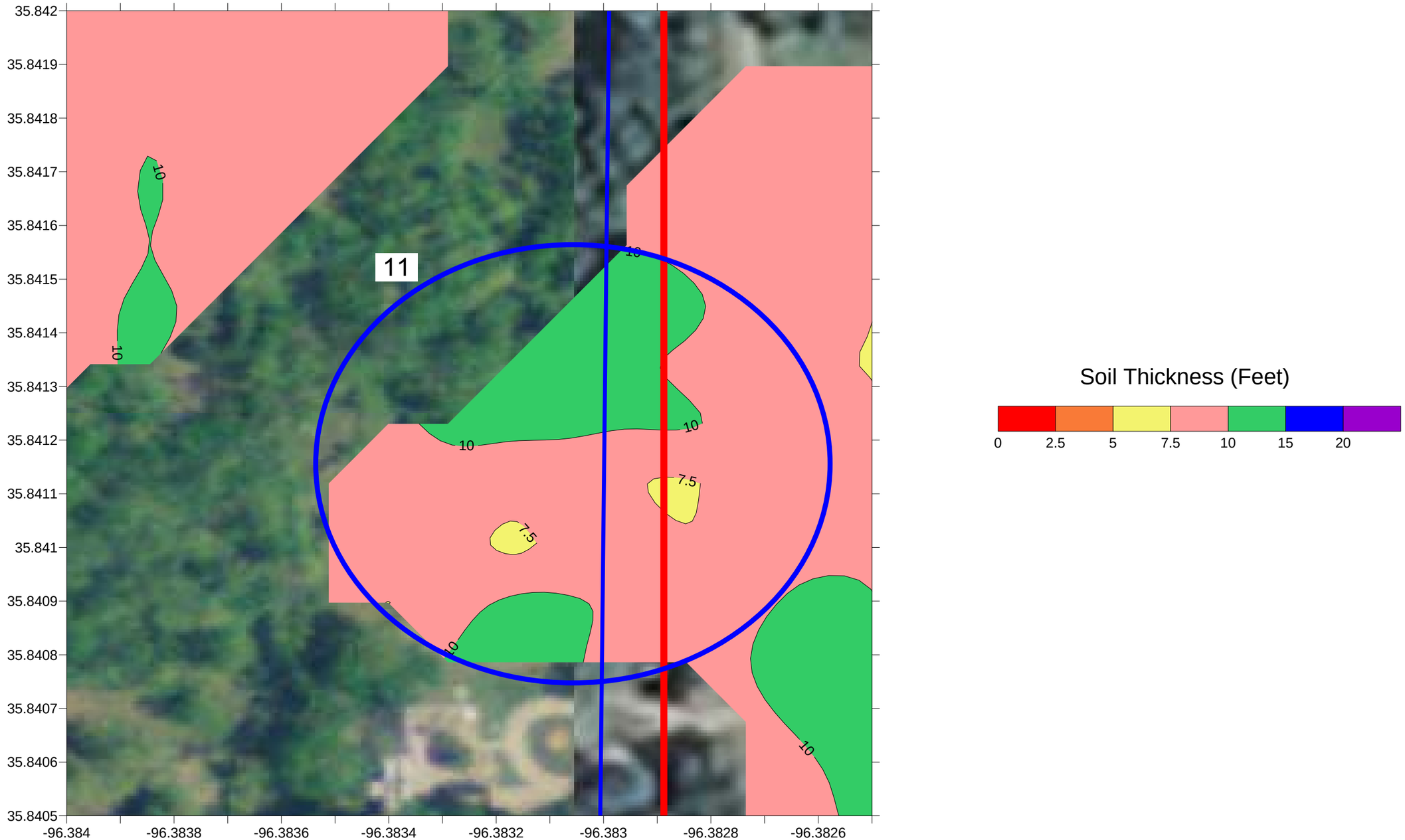
N

W E

S

Figure 54
Bedrock Elevation
Investigation Area 11

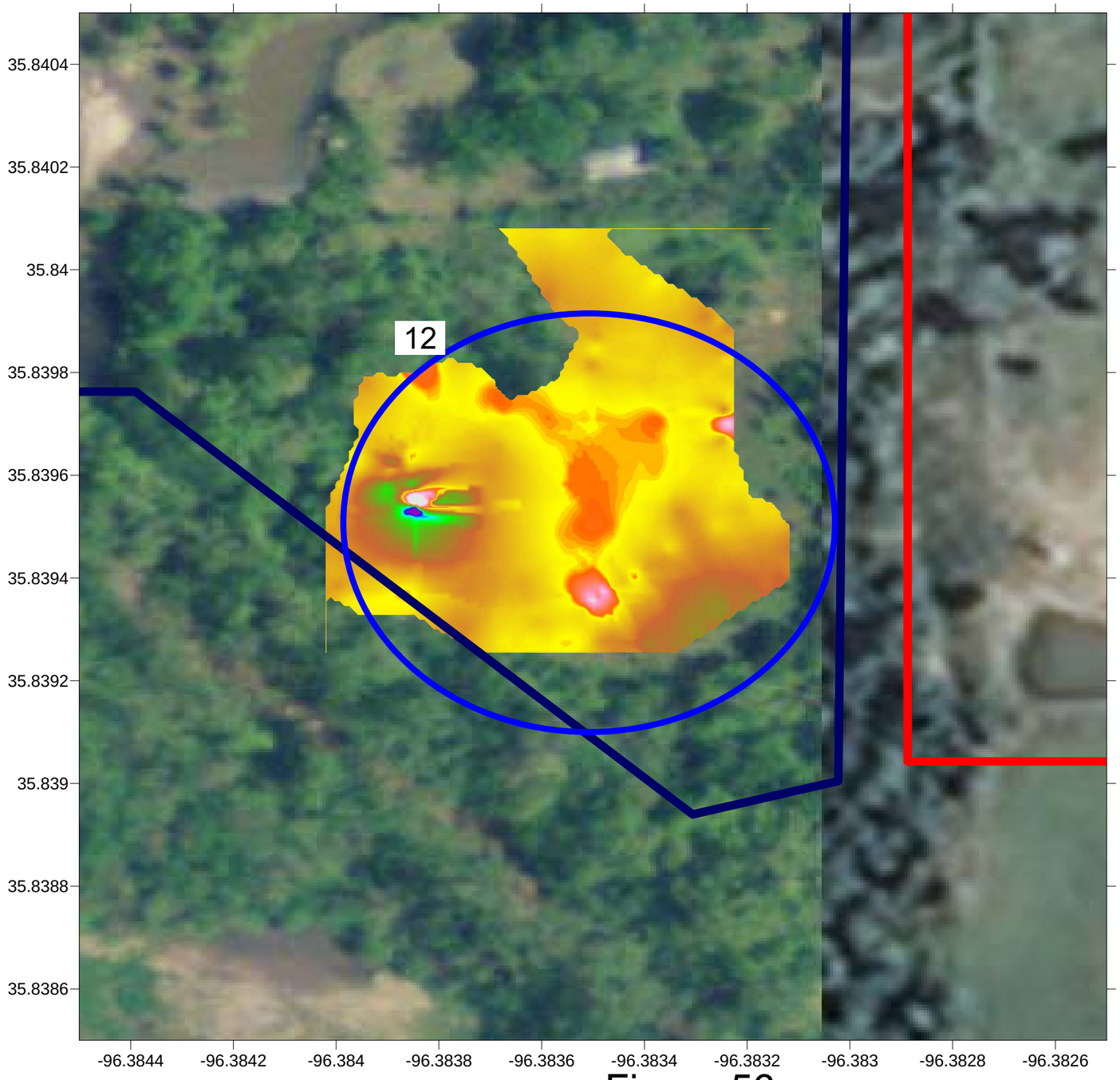
Coordinates are presented in Latitude/Longitude

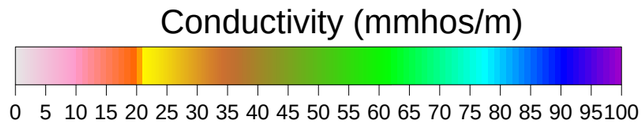


N
W
E
S

Figure 55
Soil Thickness
Investigation Area 11

Coordinates are presented in Latitude/Longitude





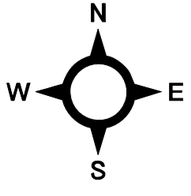
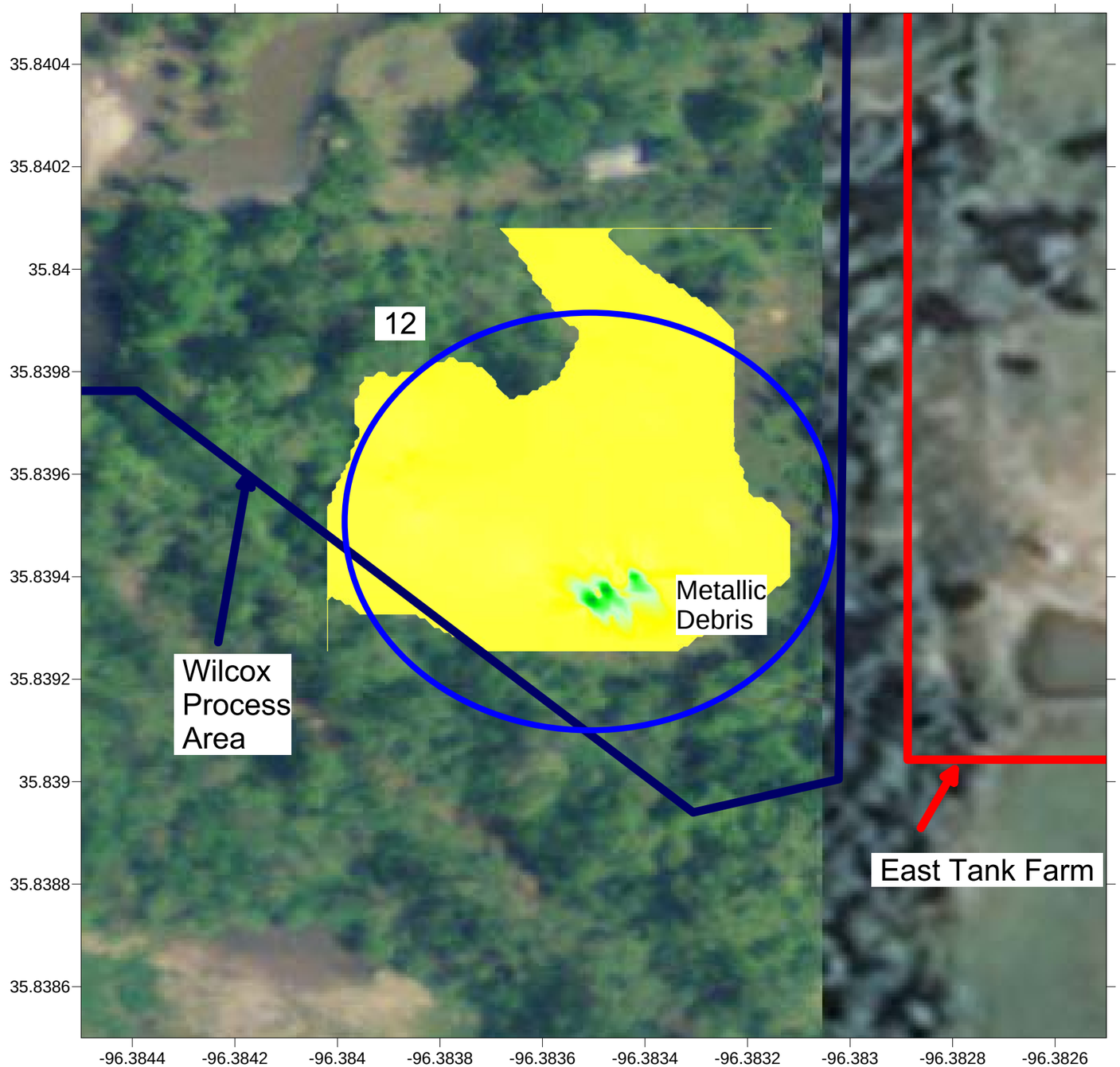
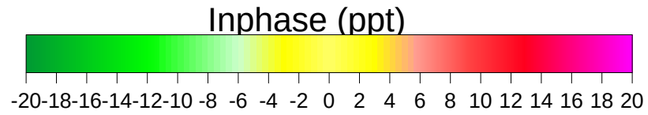


Figure 56
EM31 Conductivity Results
Investigation Area 12

Coordinates are presented in Latitude/Longitude





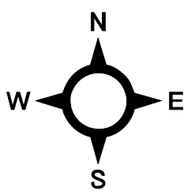
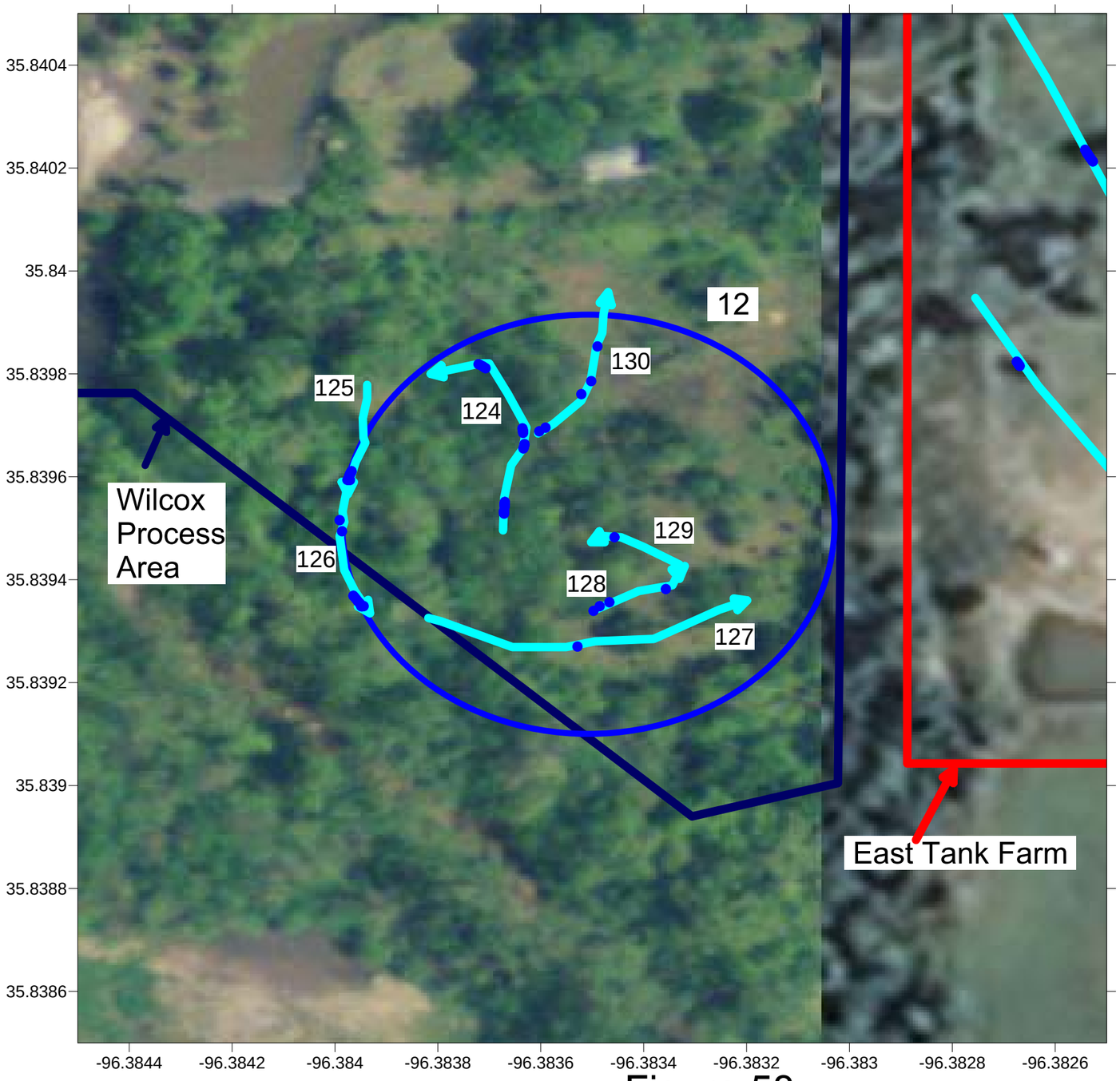


Figure 57
EM31 Inphase Results
Investigation Area 12

Coordinates are presented in Latitude/Longitude



GPR Anomaly Location

66 → Location of GPR Profile With Direction of Travel And Identifier

Figure 58
Locations of GPR Traverses and Anomalies
Investigation Area 12

Coordinates are presented in Latitude/Longitude

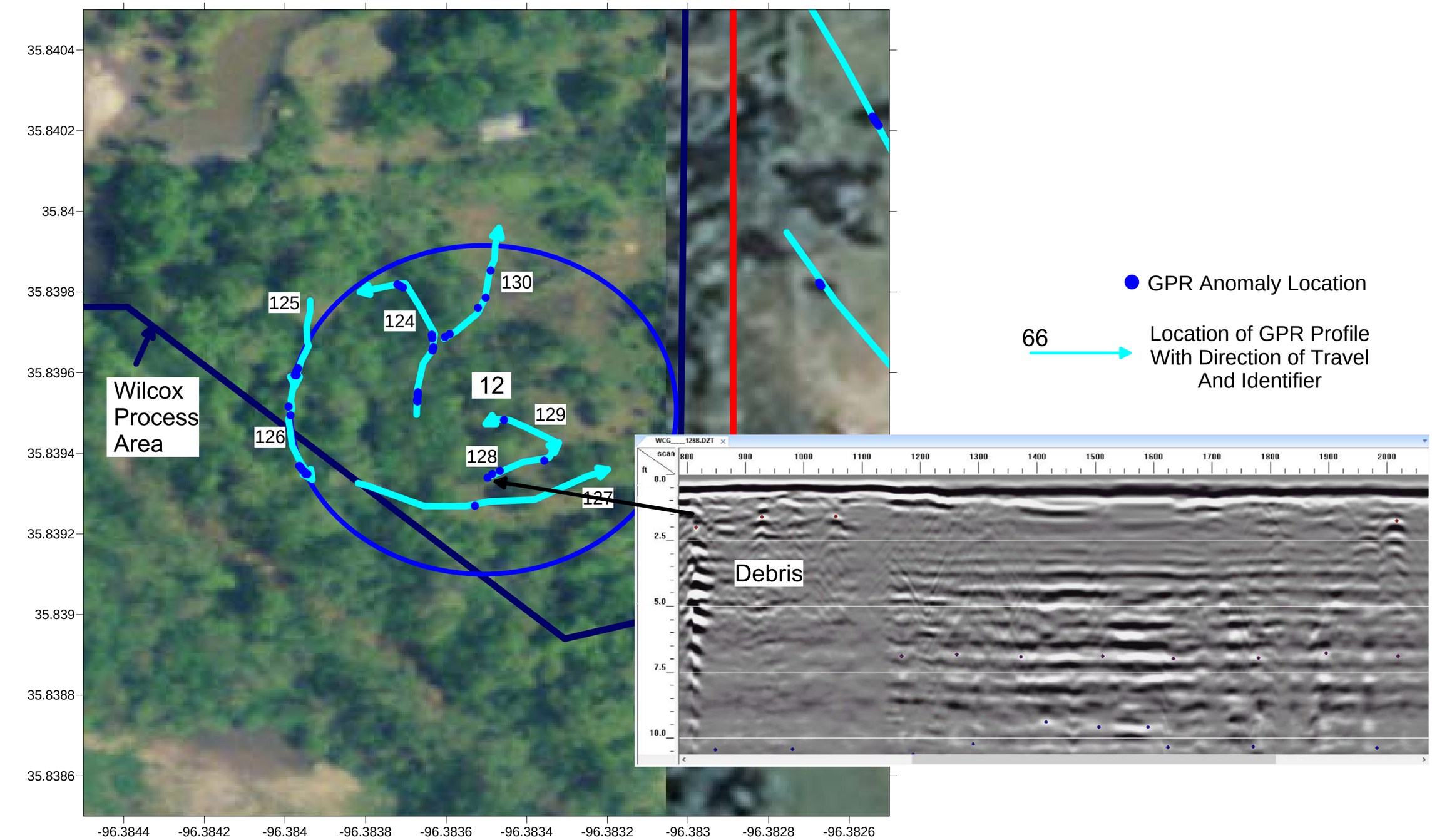
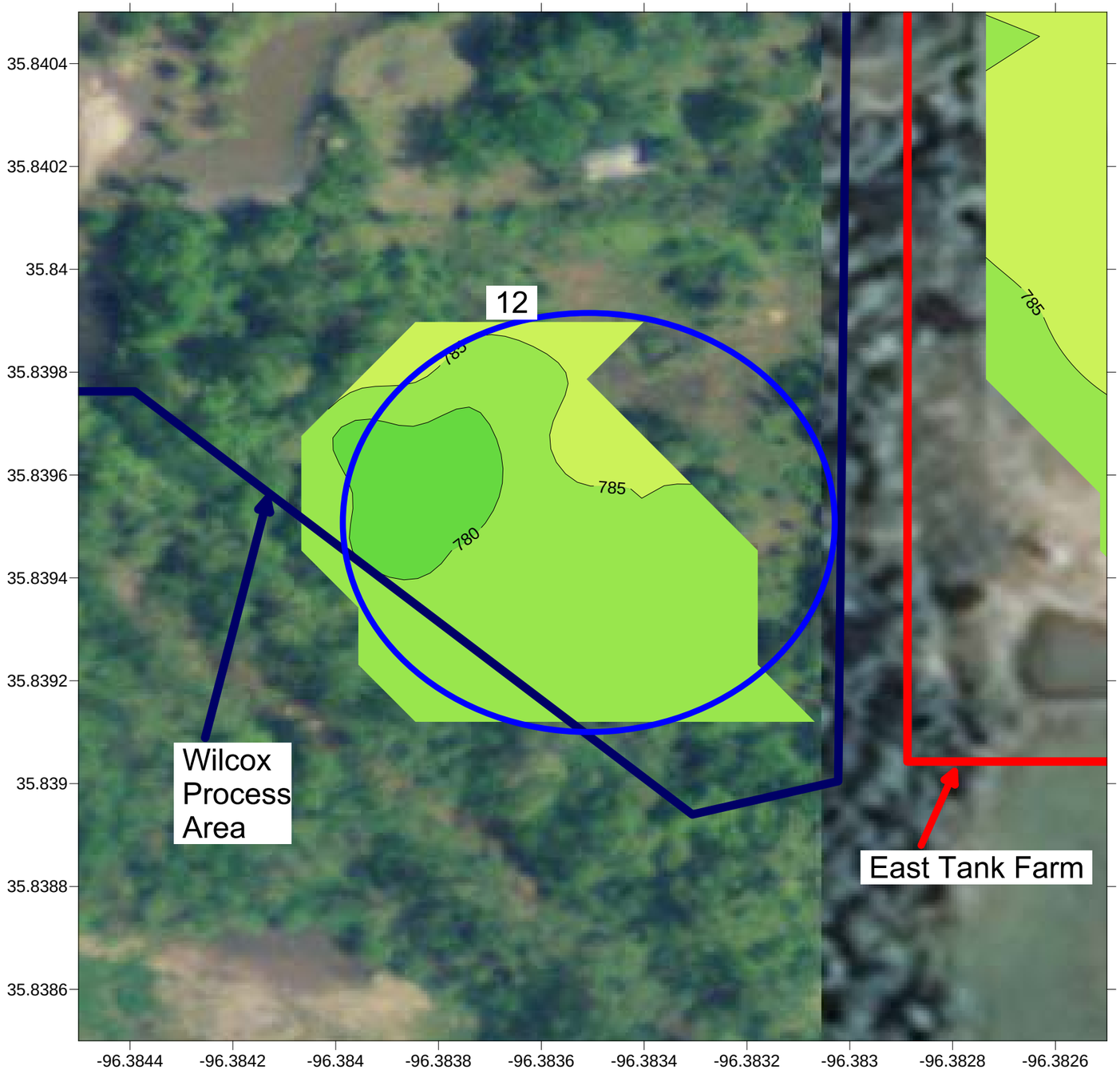


Figure 59
GPR Profiles
Investigation Area 12

Coordinates are presented in Latitude/Longitude



Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

N
W
E
S

Figure 60
Bedrock Elevation
Investigation Area 12

Coordinates are presented in Latitude/Longitude

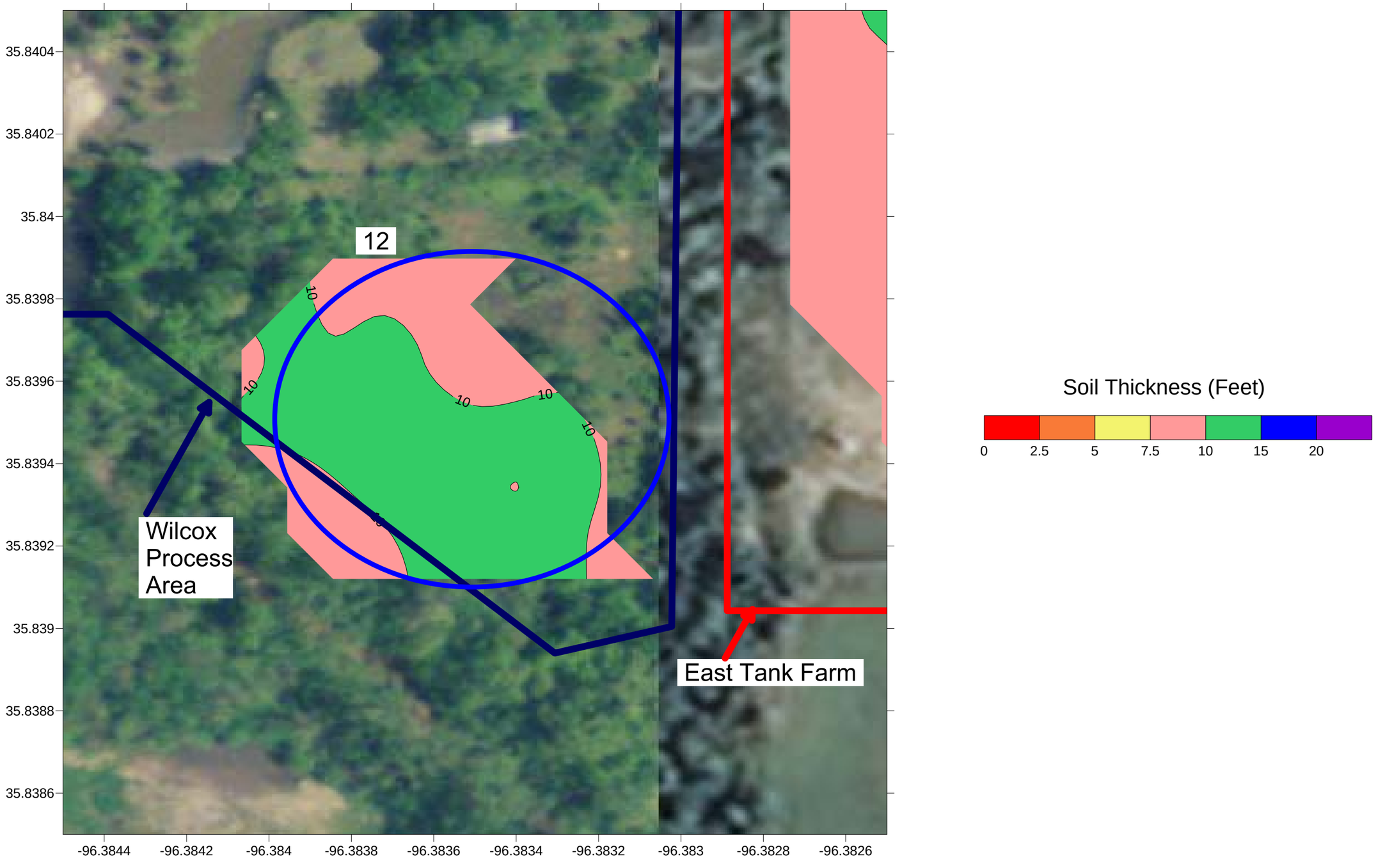


Figure 61
Soil Thickness
Investigation Area 12

Coordinates are presented in Latitude/Longitude

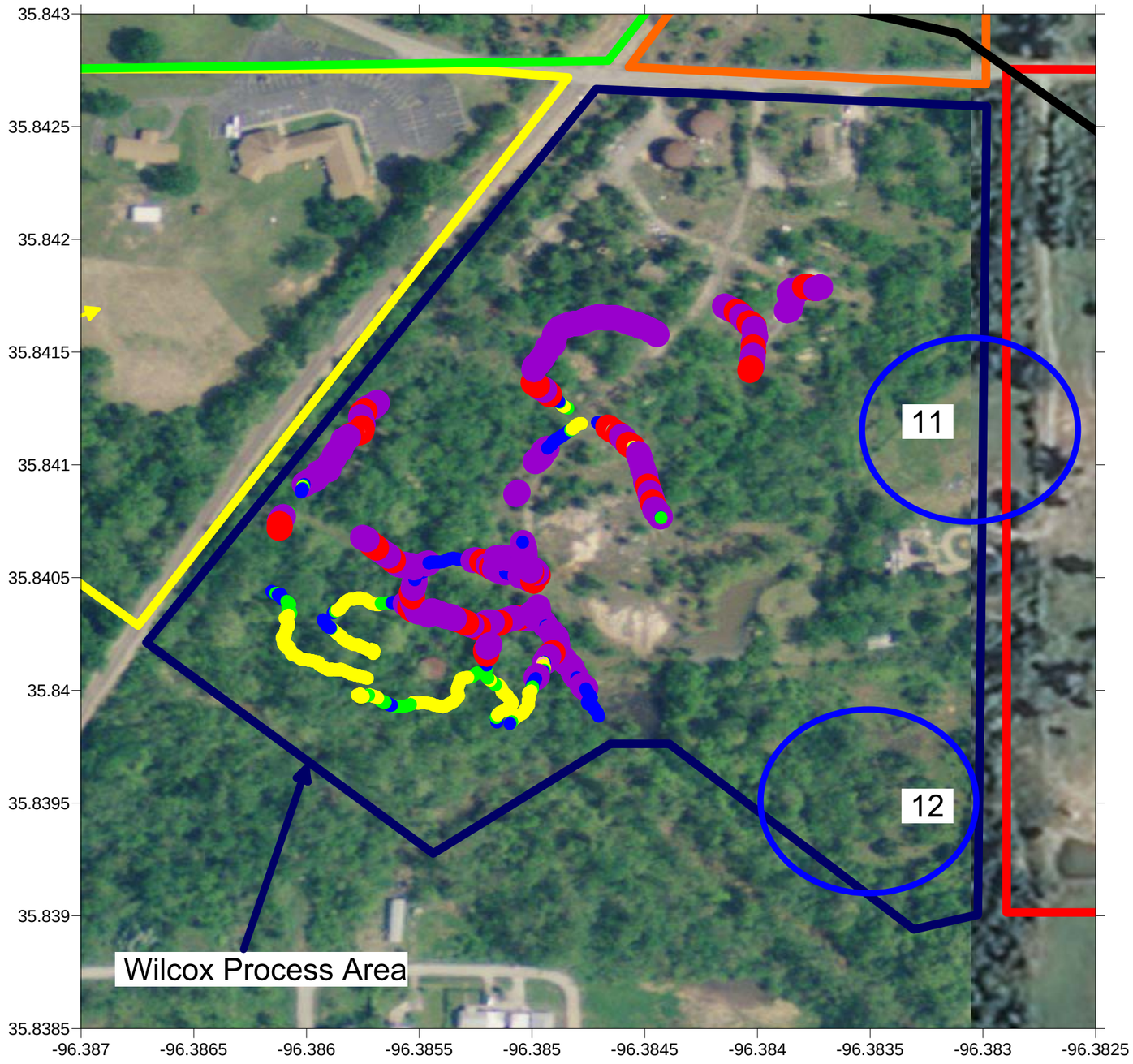


Figure 62
EM31 Conductivity Results
Wilcox Processing Area

Coordinates are presented in Latitude/Longitude

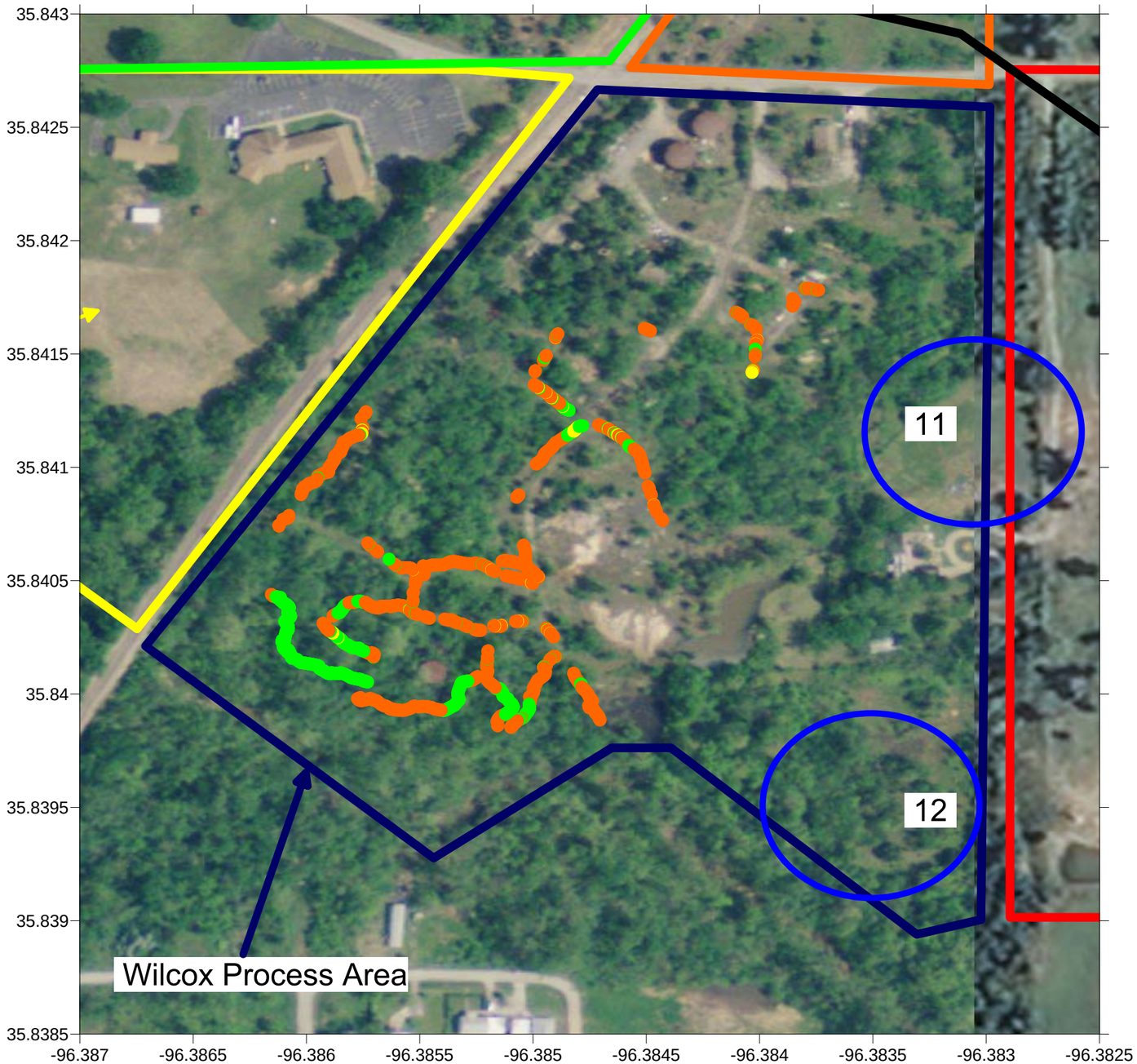
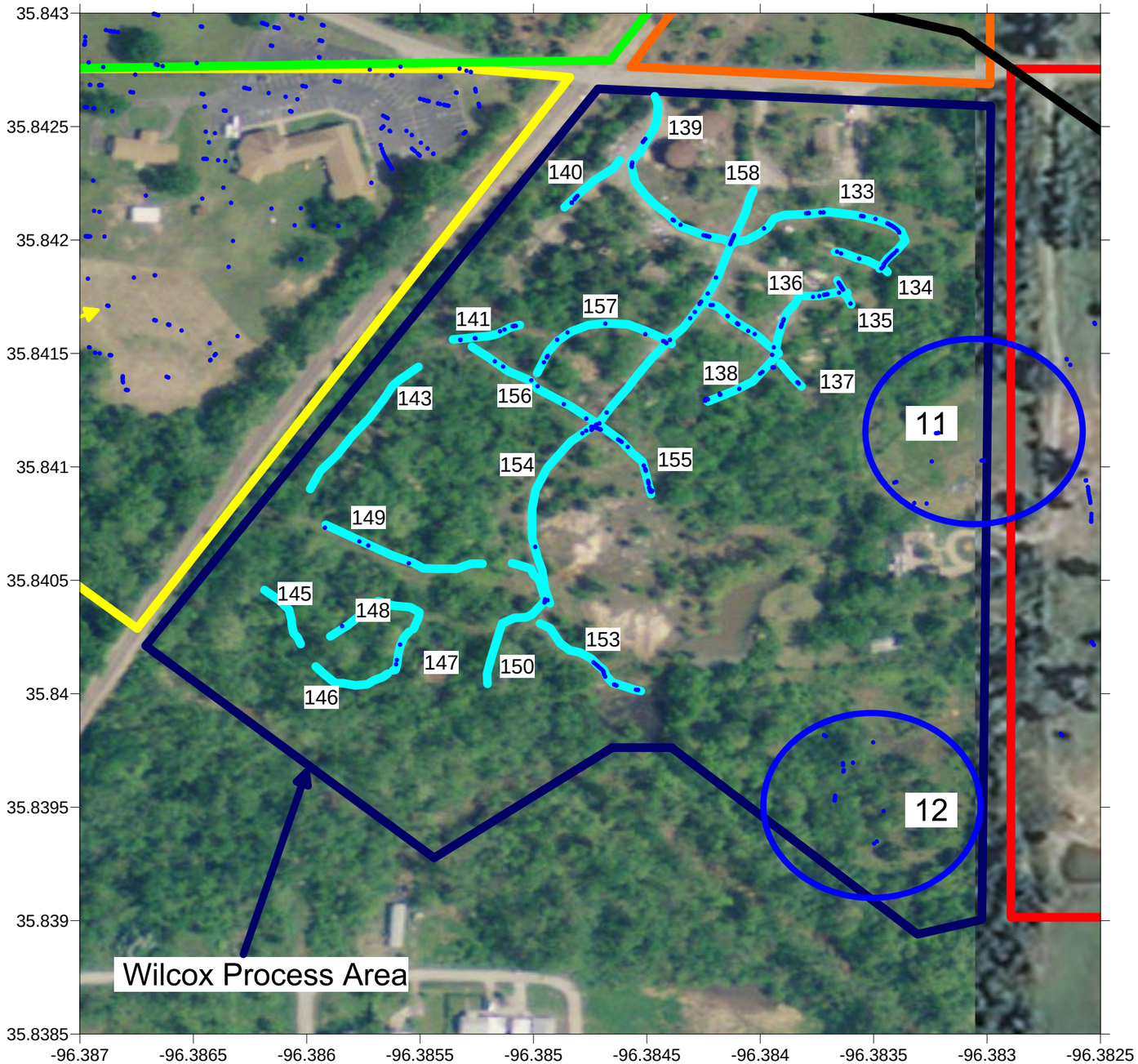


Figure 63
EM31 Inphase Results
Wilcox Processing Area

Coordinates are presented in Latitude/Longitude



GPR Anomaly Location

66 → Location of GPR Profile With Direction of Travel And Identifier

N
W E
S

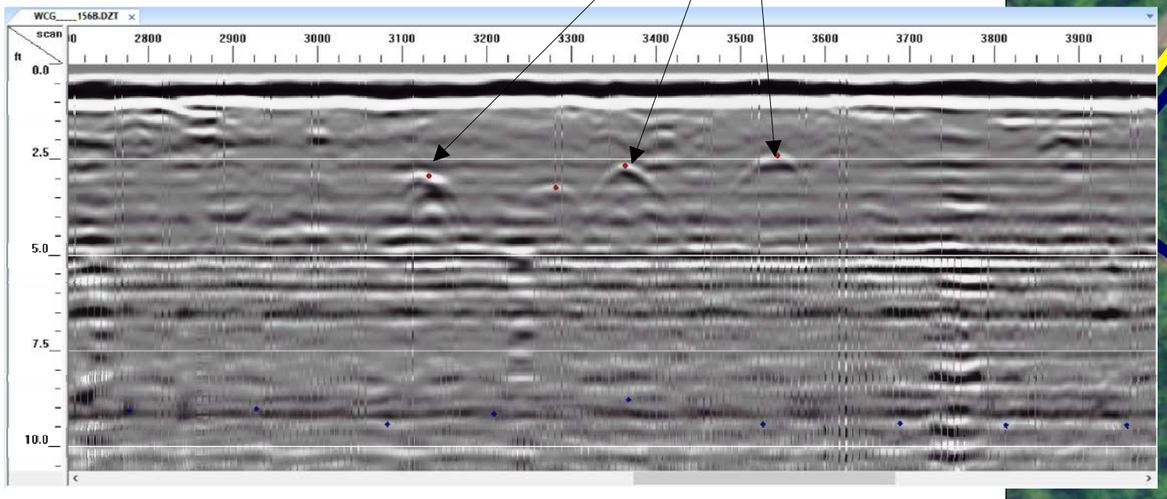
Figure 64
Locations of GPR Traverses and Anomalies
Wilcox Processing Area

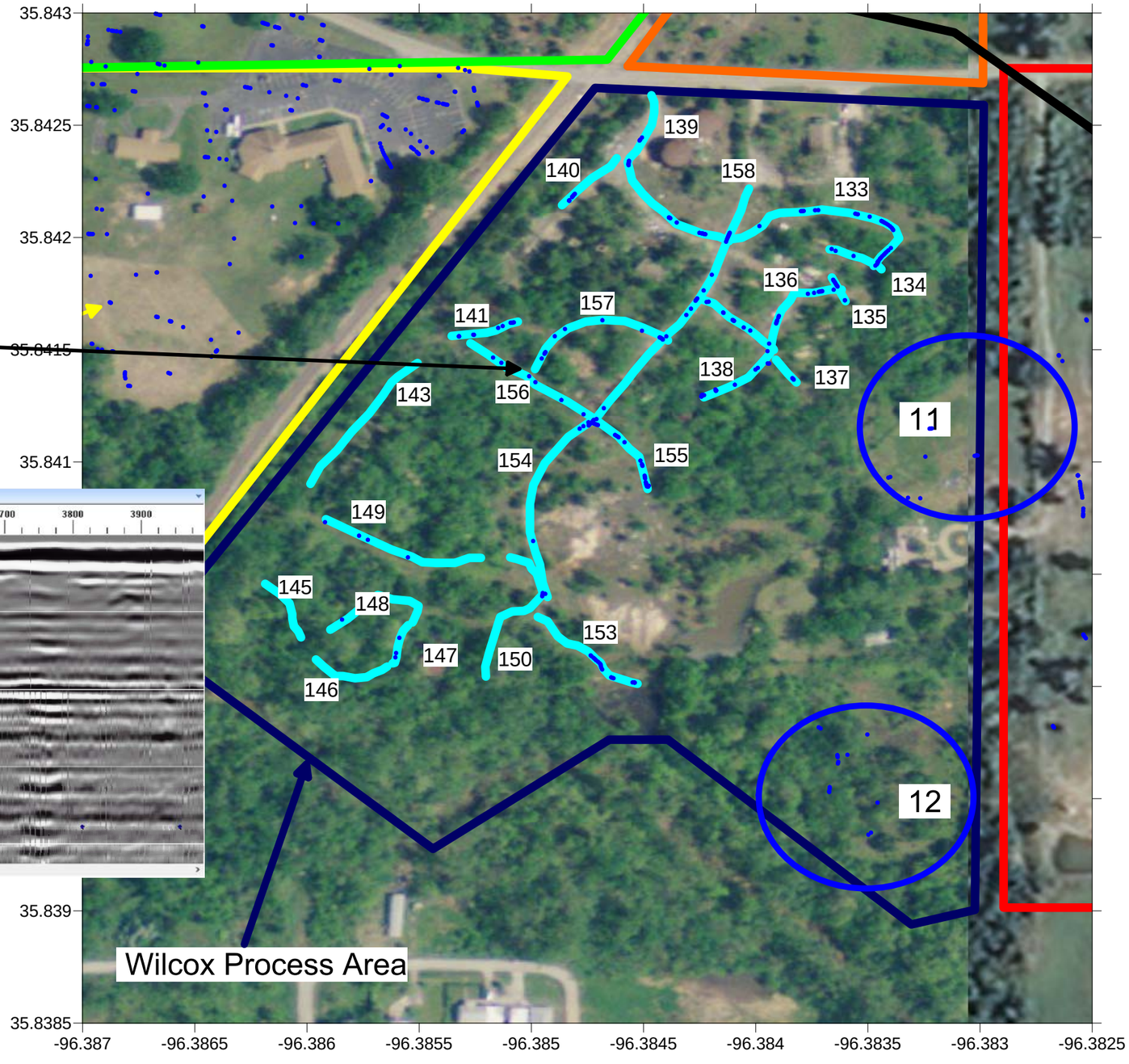
Coordinates are presented in Latitude/Longitude

● GPR Anomaly Location

66 → Location of GPR Profile With Direction of Travel And Identifier

Pipe-like Anomalies

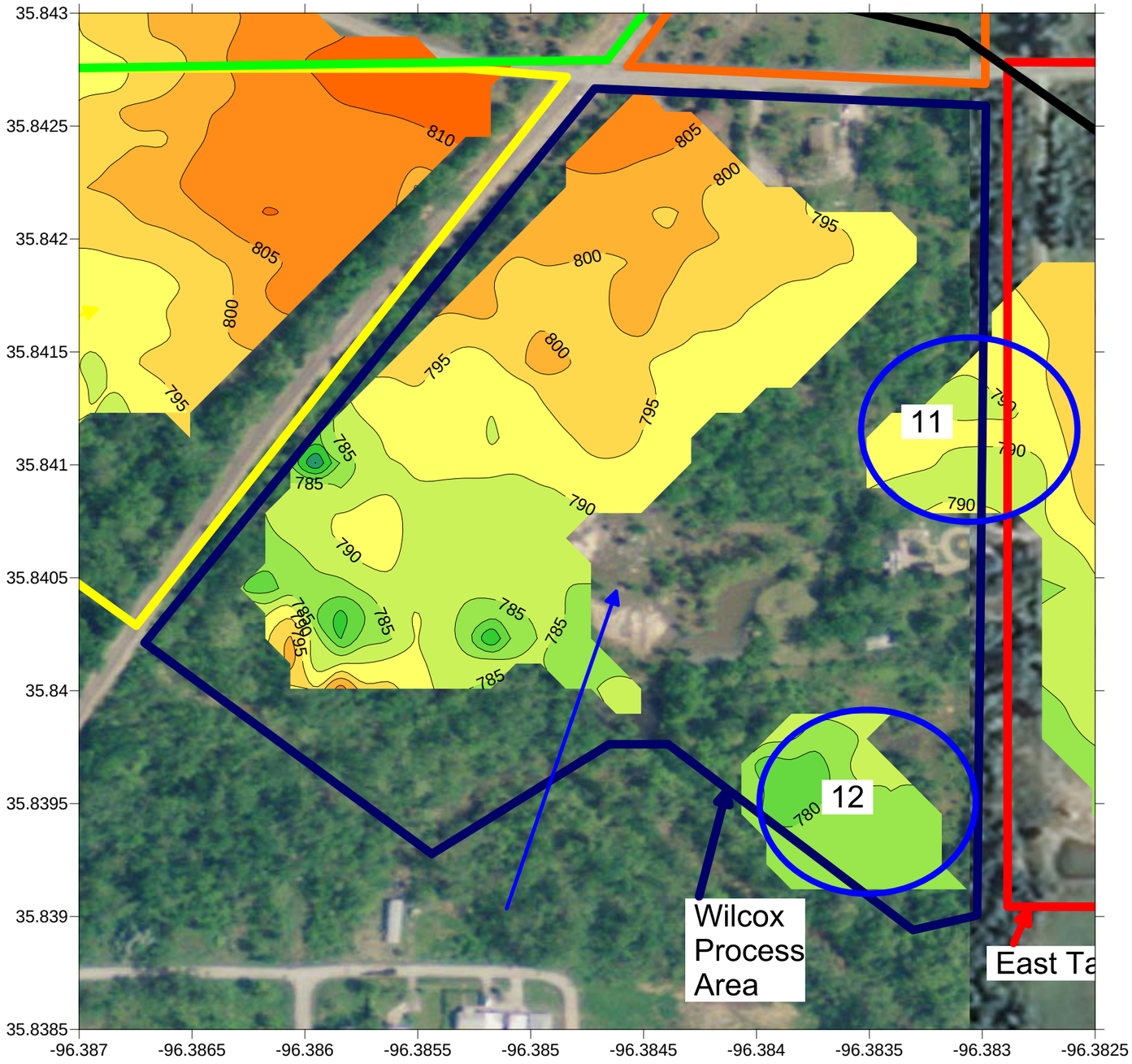




N W E S

Figure 65
GPR Profiles
Wilcox Processing Area

Coordinates are presented in Latitude/Longitude



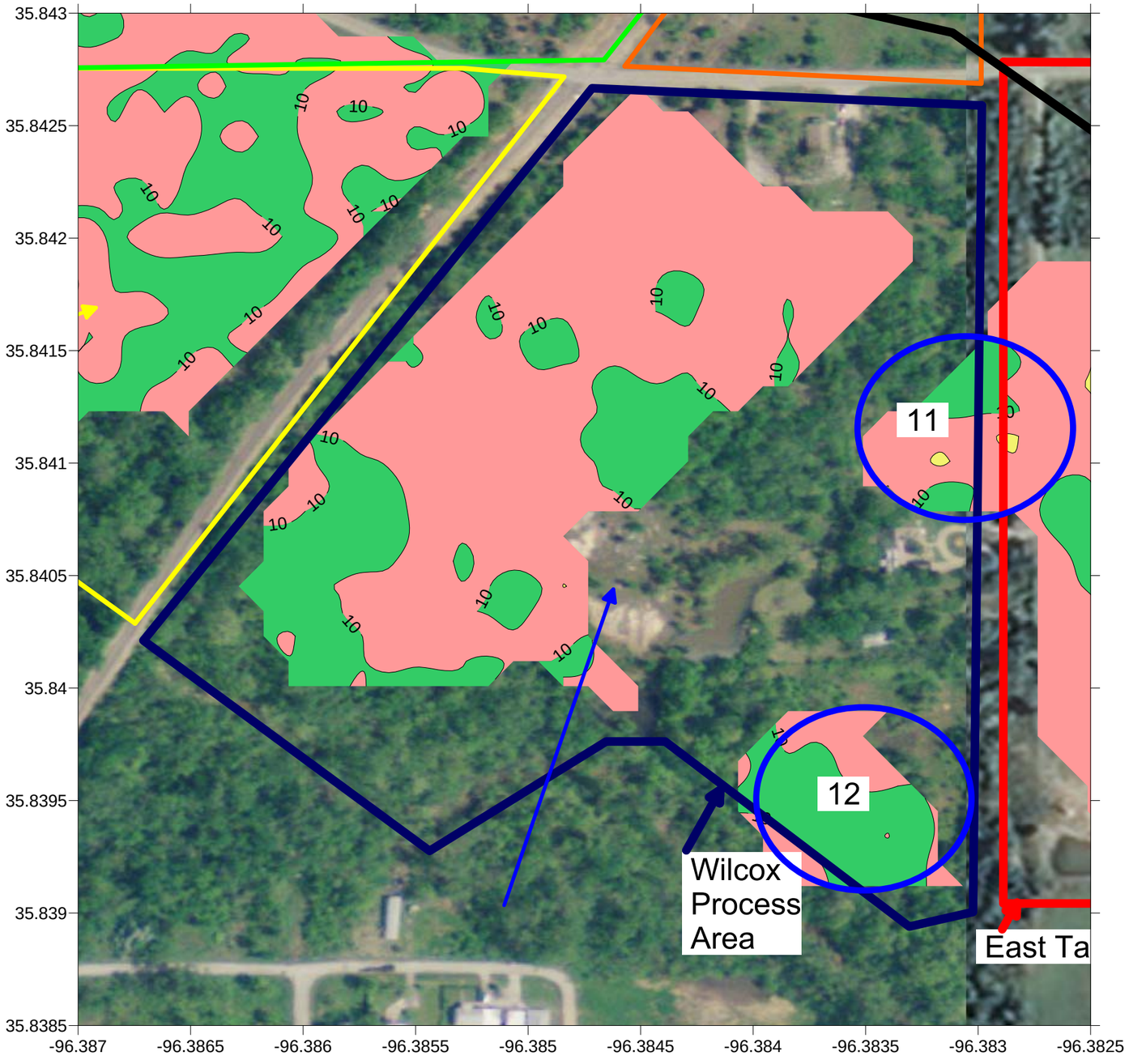
Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

N
W
E
S

Figure 66
Bedrock Elevation
Wilcox Processing Area

Coordinates are presented in Latitude/Longitude



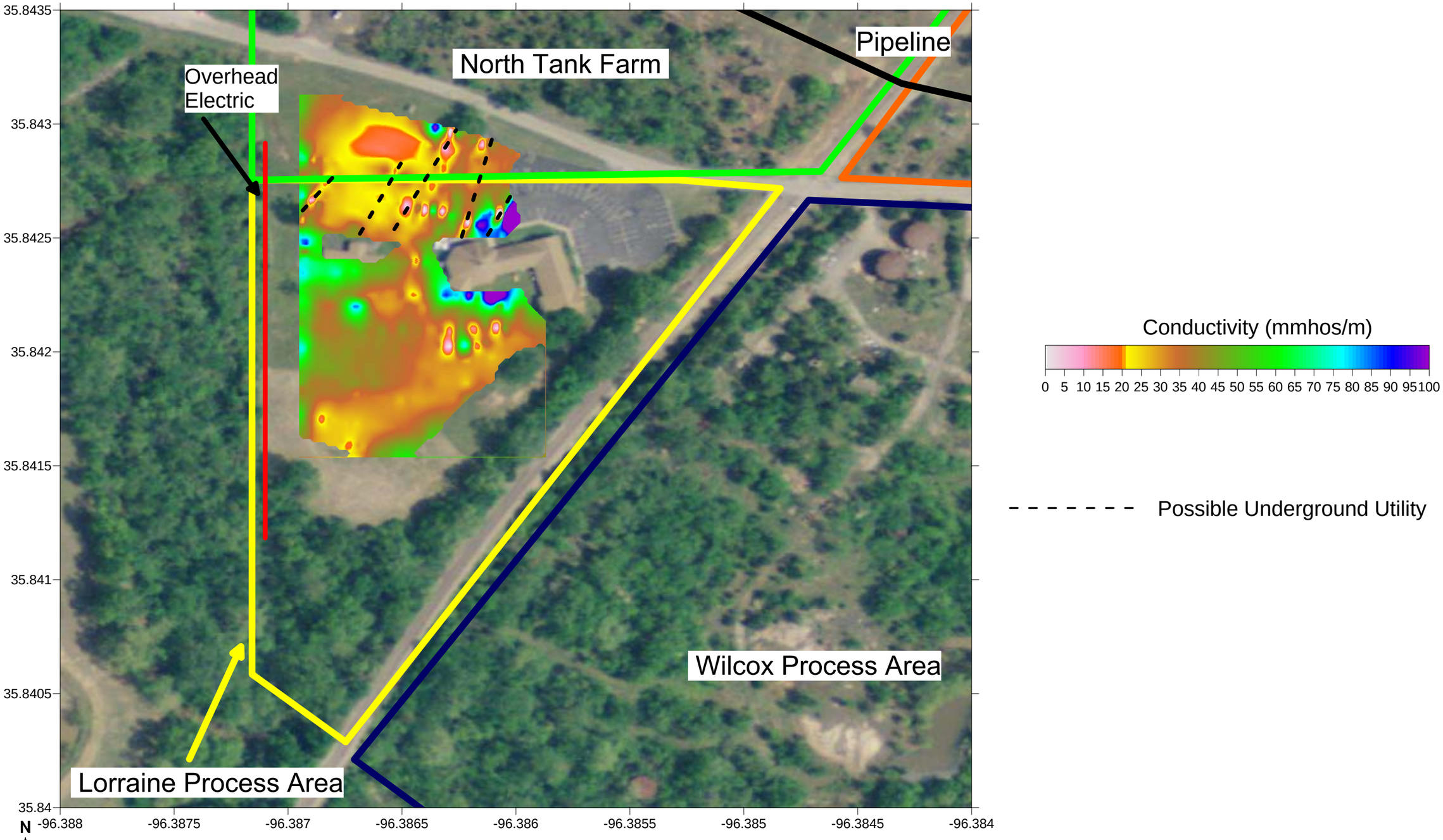
Soil Thickness (Feet)

0 2.5 5 7.5 10 15 20

N
W E
S

Figure 67
Soil Thickness
Wilcox Processing Area

Coordinates are presented in Latitude/Longitude



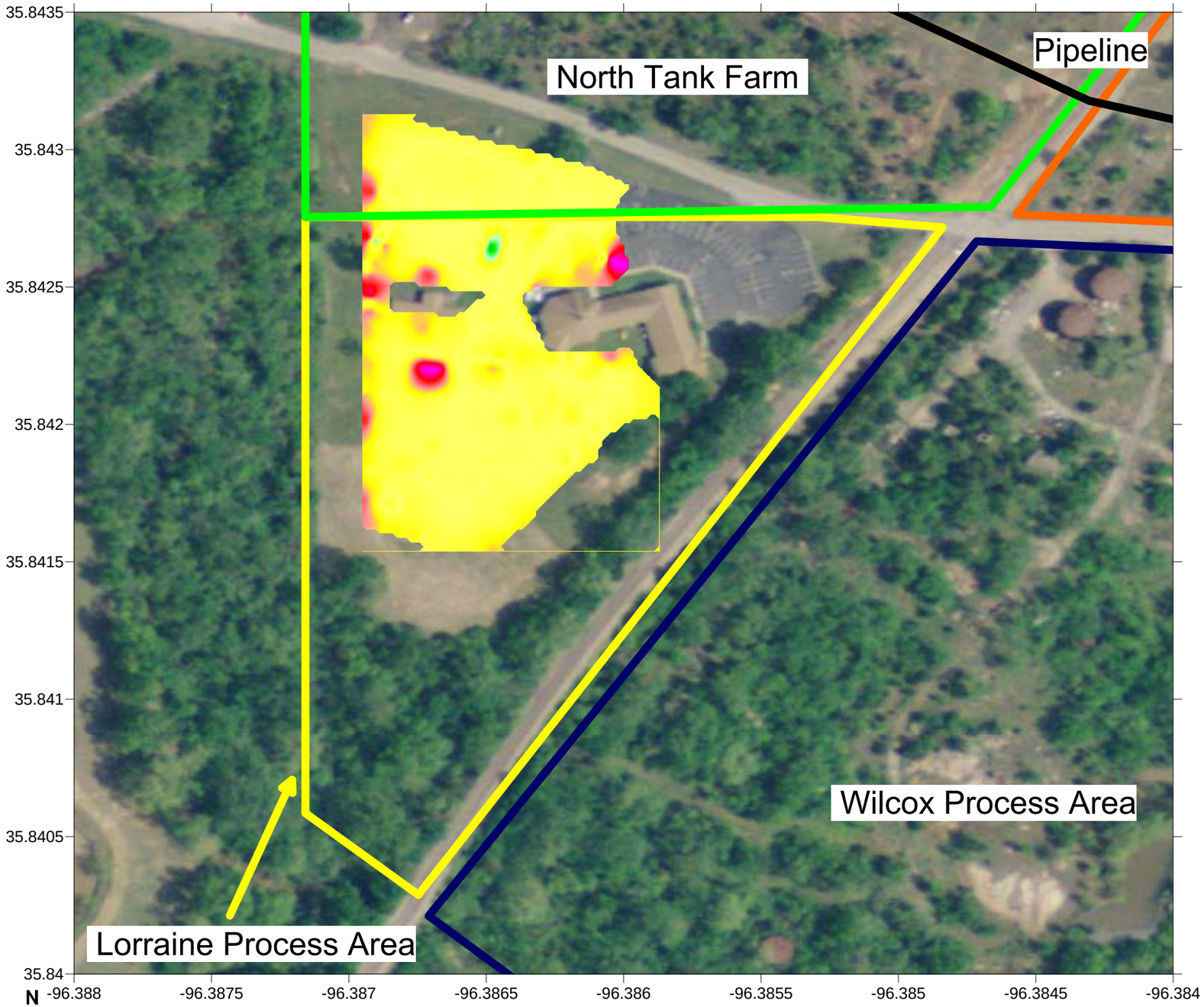
Conductivity (mmhos/m)

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

Possible Underground Utility

Figure 68
EM31 Conductivity Results
Lorraine Processing Area

Coordinates are presented in Latitude/Longitude



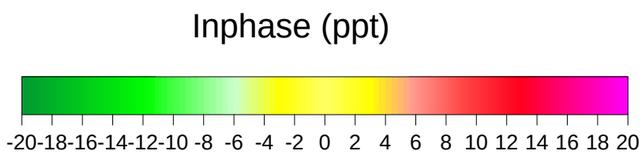
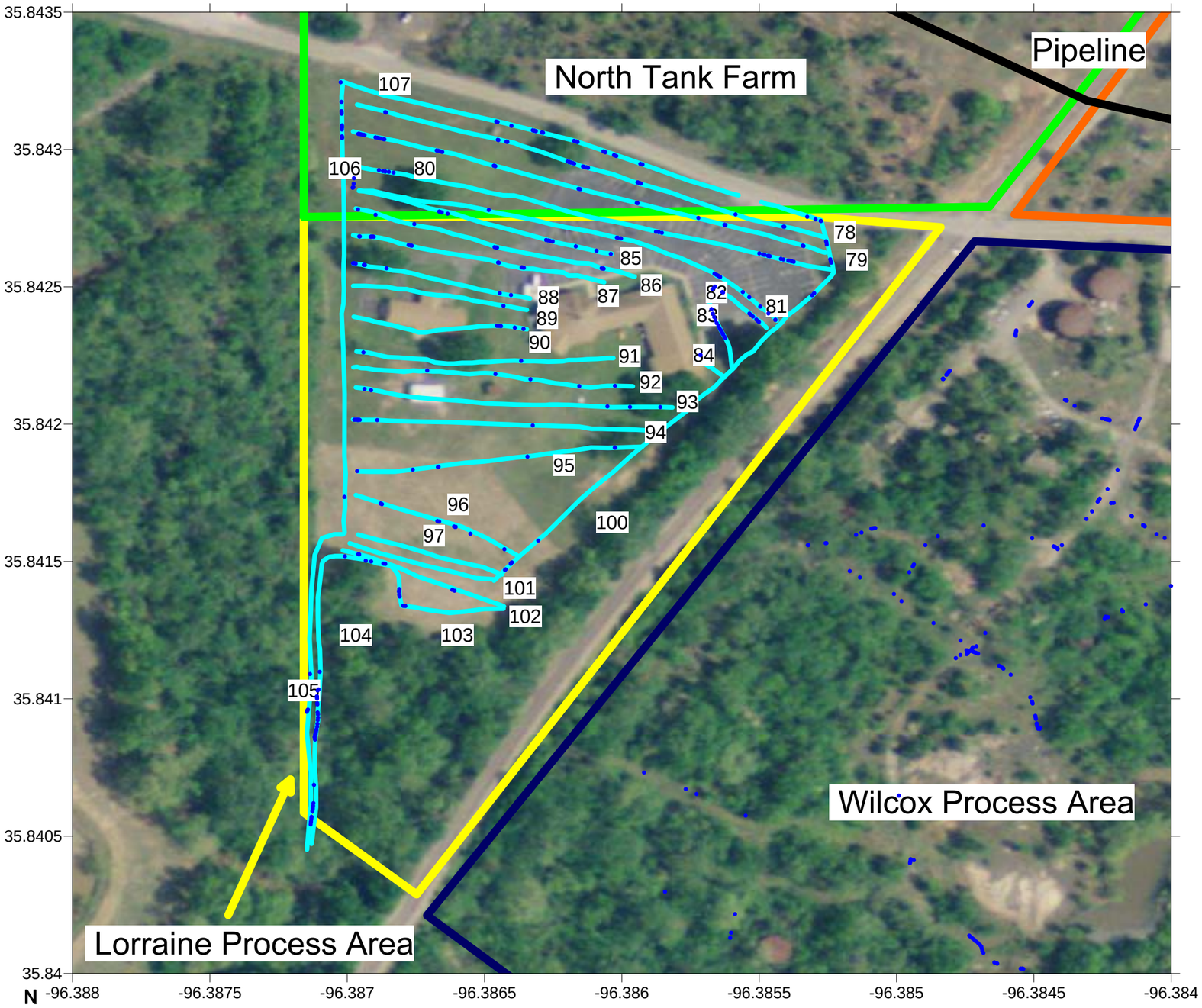


Figure 69
EM31 Inphase Results
Lorraine Processing Area

Coordinates are presented in Latitude/Longitude

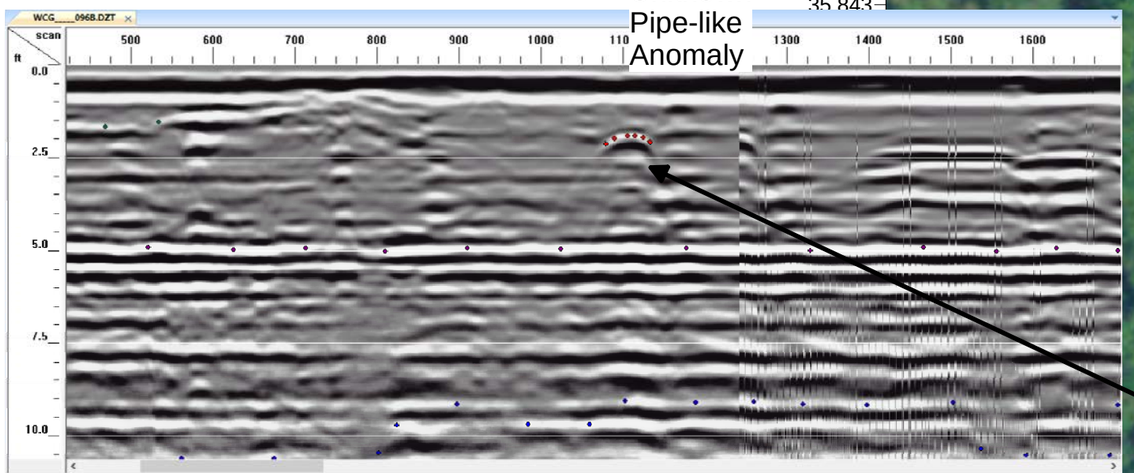


GPR Anomaly Location

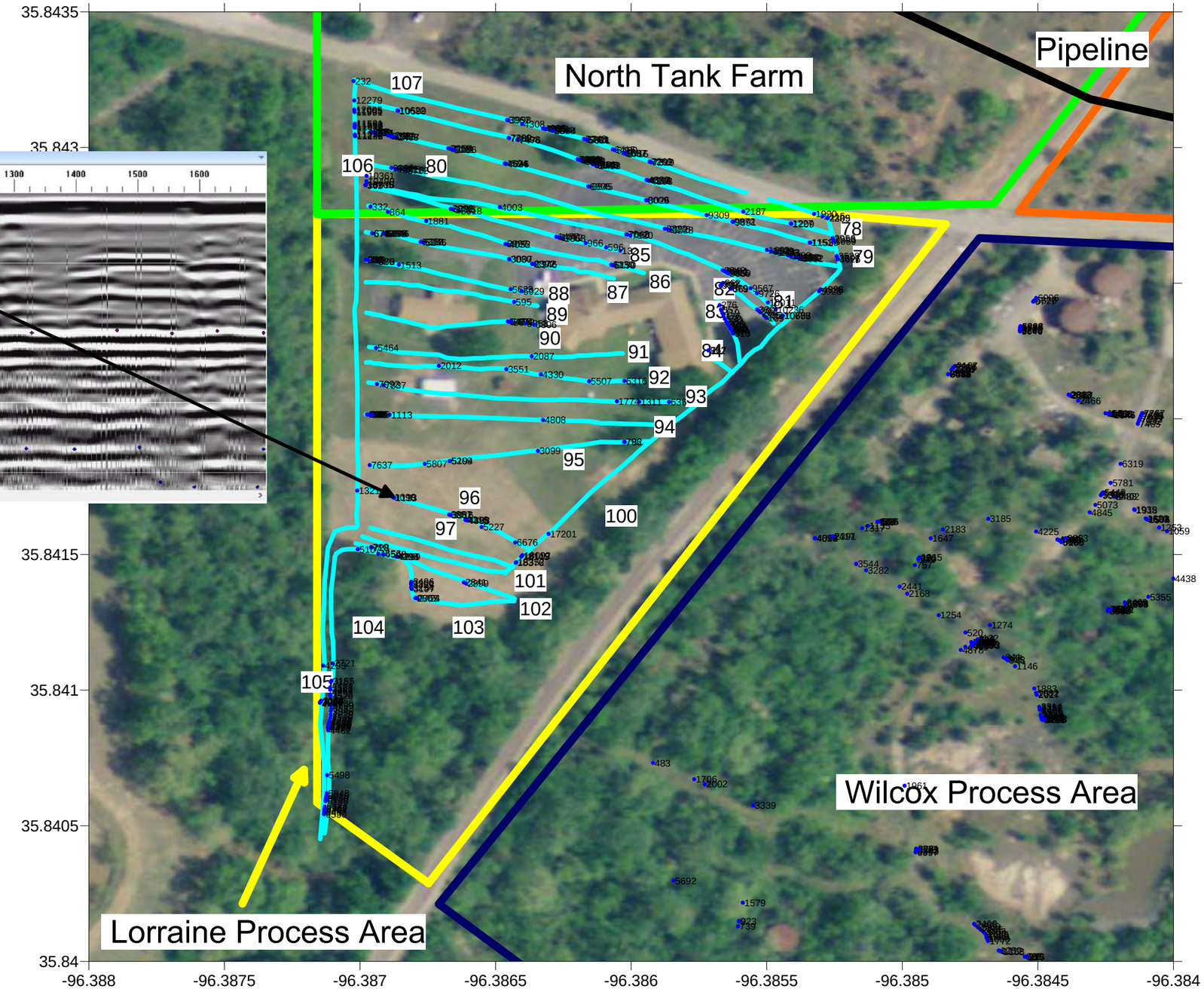
91 → Location of GPR Profile With Direction of Travel And Identifier

Figure 70
Locations of GPR Traverses and Anomalies
Lorraine Processing Area

Coordinates are presented in Latitude/Longitude



Unknown Pipe-like Anomaly



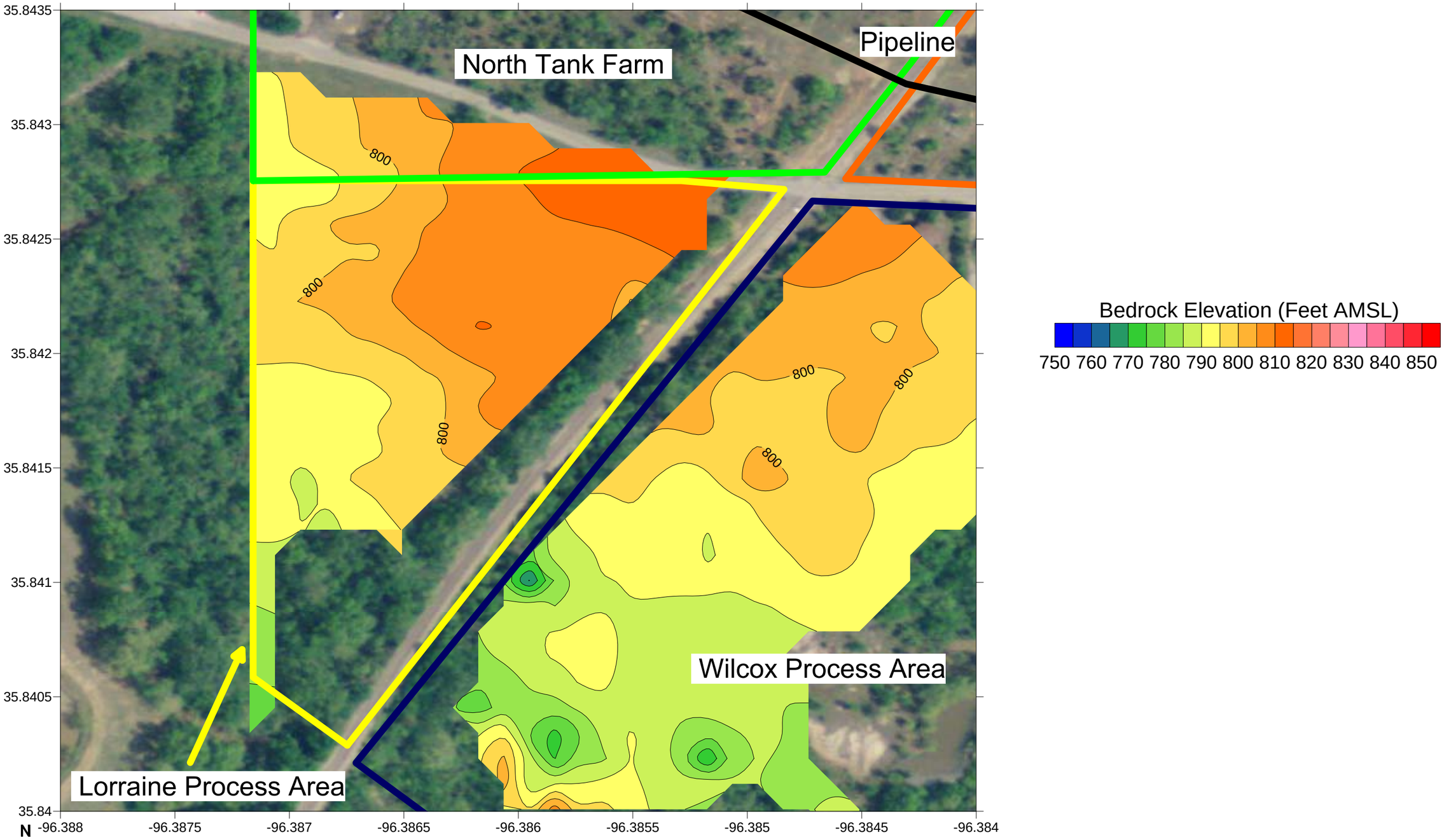
● GPR Anomaly Location

91 → Location of GPR Profile With Direction of Travel And Identifier

N
W
E
S

Figure 71
GPR Profiles
Lorraine Processing Area

Coordinates are presented in Latitude/Longitude

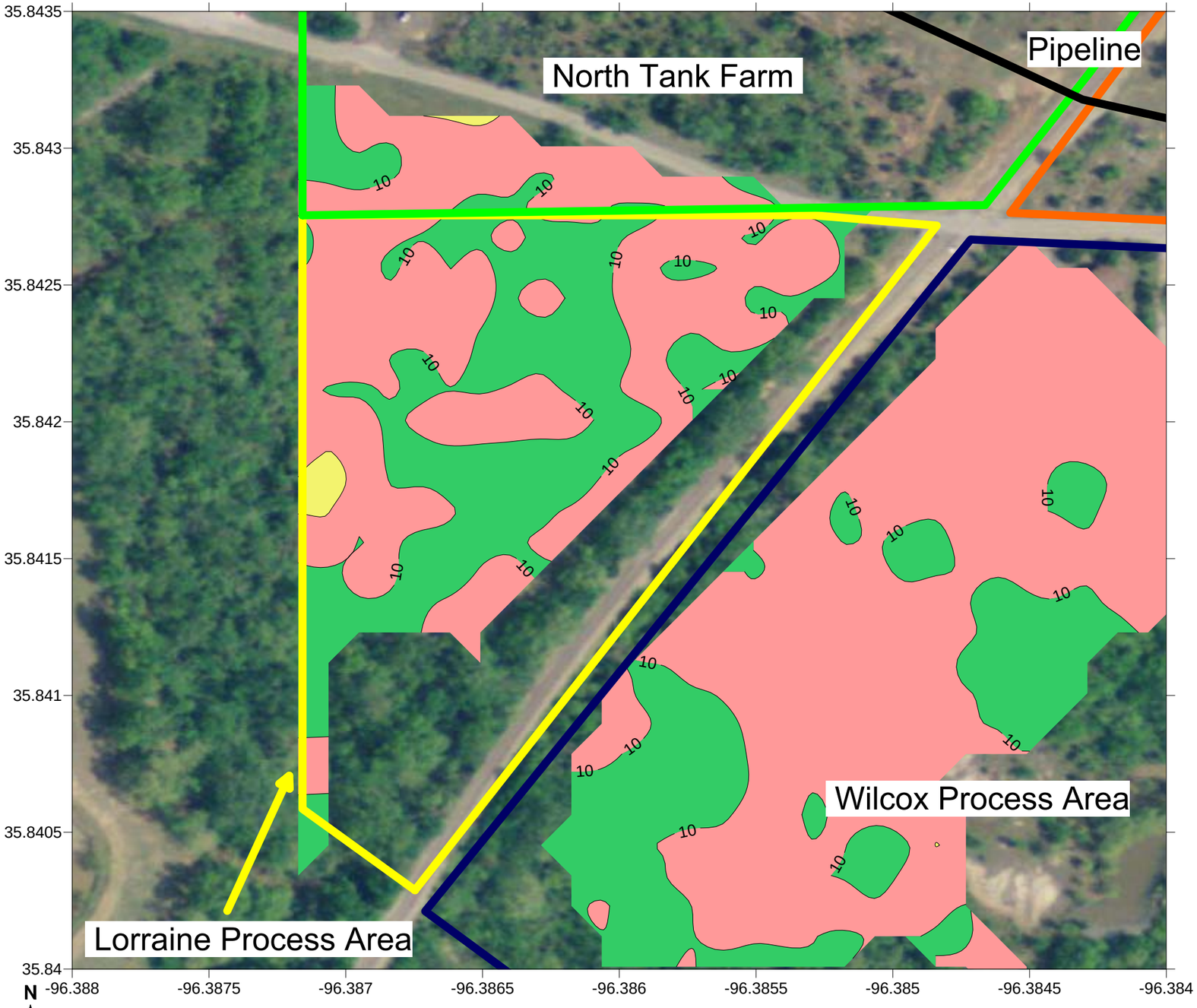


Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

Figure 72
Bedrock Elevation
Lorraine Processing Area

Coordinates are presented in Latitude/Longitude



Soil Thickness (Feet)

0 2.5 5 7.5 10 15 20

N W E S

Figure 73
Soil Thickness
Lorraine Processing Area

Coordinates are presented in Latitude/Longitude

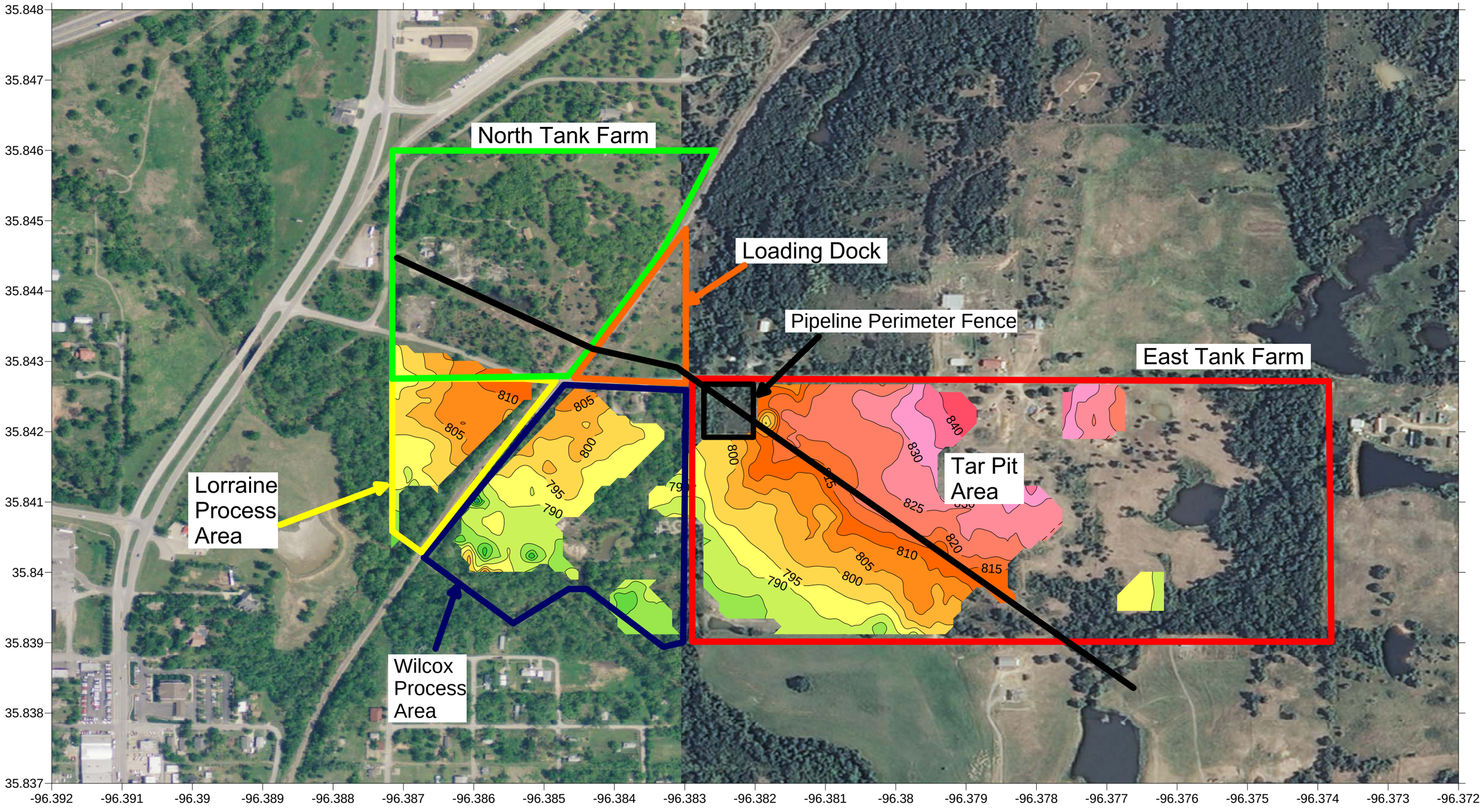
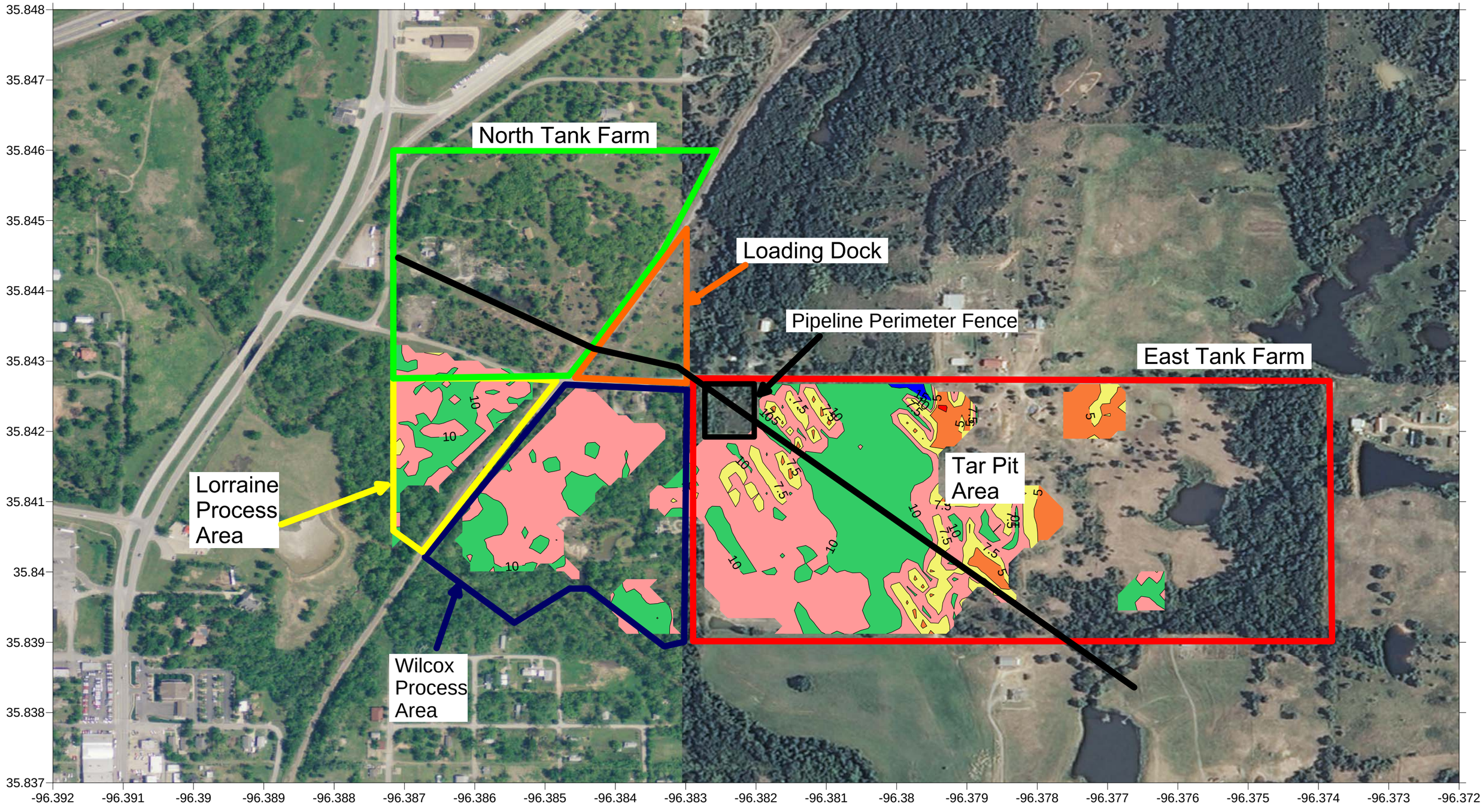


Figure 74
Sitewide Bedrock Elevation Map

Bedrock Elevation (Feet AMSL)

750 760 770 780 790 800 810 820 830 840 850

Coordinates are presented in Latitude/Longitude



N
W E
S

Figure 75
Sitewide Soil Thickness Map

Soil Thickness (Feet)

0 2.5 5 7.5 10 15 20

Coordinates are presented in Latitude/Longitude